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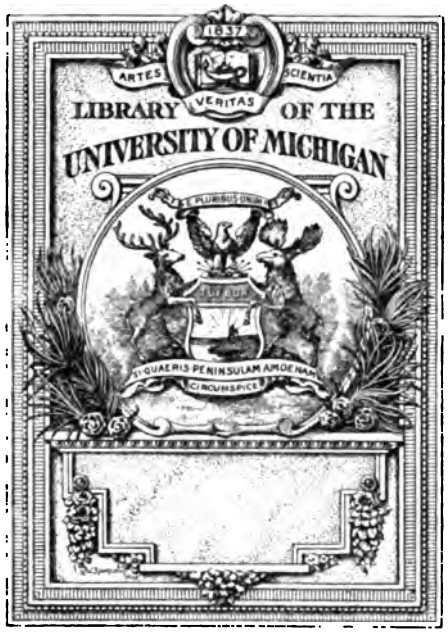
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tive—and the imperative itself being regarded as a form of statement or assertion (of a wish, etc.), the question also is regarded as a form of statement or assertion.

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In the following pages I several times refer to my articles—here cited once for all completely—on

"The Meaning and Function of Thought Connectives"—published in the "Transactions of the Wisconsin Academy of Sciences, Arts and Letters," Vol. XII, pp. 1-48, and

"A Revision of the Pronoun, with Special Examination of Relatives and Relative Clauses," l. c. Vol. XIII, pp. 1-140.

INTERROGATIVE THOUGHT AND THE MEANS OF ITS EXPRESSION.

CHAPTER I.

INTRODUCTORY OBSERVATIONS.

WORDS OR IDEA-SYMBOLS.

Words express ideas versus things.

When, as often happens, an idea is the mental counterpart of a thing, it is true that the sign of the idea is also, indirectly, the sign of the thing. But it is more accurate and, in close examination of language, quite essential, to recognize in words the immediate signs of what is mental only.

A word may express one idea.

As to what constitutes a single idea, opinion may vary. But presumably the idea suggested by "blue" or "blueness" will be accepted as single. Its presentation by a single word may be described as *Integral symbolization.*

A word may express more than one idea.

For instance "ate" expresses not only the idea of eating, but also a time idea, and quite as effectively as the phrase "in past time." Such symbolization may be known as *Multiple.*

A word may express less than one idea.

That is, in particular, it may co-operate with another word in expressing one idea. Thus in French the symbols "ne" and "pas" accomplish together no more than the English "not." The symbolization of each may be distinguished as *Fractional.*

SENTENCES OR THOUGHT-SYMBOLS.

Sentences express thoughts versus ideas.

The single word being normally the expression of a single idea, that combination of words which is called a sentence will normally express a plurality of ideas. Not every such plurality is however available for sentential expression. Without discussion it may be merely postulated for the present, that no aggregation of words is a sentence, unless it expresses a thought; and that no aggregation of ideas is a thought, unless it contains two ideas and a relation of some sort between them. (See pp. 362 and 367.) For instance, given "Orange exceeds lemon", if any word be omitted, the remainder is not a sentence; and what that remainder expresses is not a thought.

Sentences express thoughts versus extra-mental facts.

When I say, for instance, that the sun has passed behind a cloud, I doubly violate the presumable physical truth. The "passage" is not that of the sun; and what I suggest by the word "behind" has no existence, except in the mind of an observer specially situated. But my expression successfully indicates what I have thought; and that is all that language intends. It is true that I strive to harmonize my thoughts with external facts. It may then be admitted that these facts are what the sentence indirectly aims to present. But it is more accurate and, in close examination of language, quite essential to recognize in sentences the immediate symbols, on a larger scale than words, of mental phenomena only.*

Sentences express thoughts versus other mental facts.

Among the actual phenomena of mind, must doubtless be included desires and emotions. These, and also the sensations of the body, are undeniably the frequent burden of speech. But they are such only indirectly. I am likely enough, for instance,

*That these mental phenomena themselves are facts is obvious. They are however subjective facts, being readily differentiated from the objective facts of the extra-mental universe. Also even the thought of one instant may become objective or external to the thought of the next, as when one makes a thought of his own the theme of further mental operation.

to tell you of my fear. A sentence by which I do so will not, however, express a fear itself, but rather my idea of fear.

To illustrate, compare the sentences "Brown fears your dog", "I do not fear him", "I should dislike to fear him", "I shall fear him". In all of these the idea of fear may be distinguished from the emotion of fear, as clearly as the idea of the dog can be distinguished from the dog himself. It is plainly also the idea of fear, and not the emotion itself, that is expressed by what I say. When now I say, "I fear your dog", I see no reason to suppose that the meaning of the symbol "fear" has changed. The fact that, in the present illustration, I am actually afraid (while speaking) is no more a proof that I express the fear itself, than the fact that my teeth are at the same time aching, is a proof that the words "I fear your dog" express the tooth-ache.*

Sentences express thoughts formed in a particular way.

To illustrate, seeing the contractor, Mr. Brown, and also an Italian workman, and being curious to learn in what way, if any, they are in relation, I discover that their relation is that of employer to employee. My discovery I announce by the sentence "Brown employs an Italian."

In the thought which I thus express, the ideas named by "Brown" and "Italian" are preliminary data. What I express by "employs" is a resultant, to which I naturally accord a dominant importance. Given "Brown" and the "Italian," I develop "employs." They being my condition, this is my conclusion. "Employs" depicts the most important figure of my mental picture.

I may, however, derive my mental stimulus from a primary juxtaposition of "Brown" and "employs." Thinking first of these two, I may institute a search of a different order. Perhaps from memory, perhaps from other sources, I find that the proper element to put with the given two is "Italian." This element, unpleasantly missing at the outset, sought with effort, found with satisfaction, is naturally of dominant importance. Brown and the relation of employer to employee are preliminary data.

*The immediate vocal sequel of emotion, like that of sensation, is the purely reflex cry. But cries, although they very likely pointed the way to speech by suggesting the possibility of using sound as a means of stimulating another's mental action, are not admitted to rank as strictly language, which implies intention.

Italian is my resultant. The first two being my condition, Italian is my conclusion, the most important figure of my thought.

But I make no effort to show this by the form of my sentence. I give to "Italian" no such form or position as I gave to "employs" in the sentence which announced the discovery of a relation. I do not say that "Brown Italians the employment," (that is, the relation of employer to employee). I say, as before, "Brown employs an Italian." That is, I express, as before, the thought-form which is developed by finding a relation between terms—not the form developed by finding a term to fit a relation and another term.

So also starting with "employs" and "Italian" I may arrive at "Brown." But I shall not say that "The employing Browns the Italian" or that "The Italian is Browned by the employment." I shall say, as before, that "Brown employs an Italian."

It is true that different emphases may indicate the different forms of thought which first of all I form. The discovery of the relation may be announced by "Brown *employs* an Italian;" that of the Italian, by "Brown employs an *Italian*"; that of Brown, by "*Brown* employs an Italian." But when, for instance, I emphasize "Italian", the emphasis is an admission that my sentence is strictly inaccurate—that it fails to express the particular form of thought which I should like to express if language gave me the power. The emphasis tells you that in that particular form "Italian" is my resultant, though not appearing as such in the form of thought which my sentence expresses. It warns you that "Italian" should have the eminence which belongs to "employs" in "Brown *employs* an Italian".

The sort of thought revealed by the last expression becomes moreover the linguistic norm—employed even when the sort of thought originally formed is very different. Thus, examining in detail the impression produced by a red rose, and wishing to set before you the detailed impression, I say that "The rose is red", which I interpret as meaning that the rose and the redness are in the relation of object to its own quality. That is, the thought expressed is precisely that which I should have formed, had I passed from the successive ideas of object and color to the discovery of a qualitative relation between them.

Without examining further, I offer, merely as a working hypothesis, the assumption that, whatever be the form originally

assumed by a thought, before it is expressed by a sentence it takes the form of a pair of ideas and the relation between them.*

Sentences presuppose analysis and synthesis of thought.

While using for convenience the term analysis, I wish to be understood as omitting from its meaning any idea of separation. Also from the meaning of synthesis I wish to exclude the idea of junction. By the former I mean the recognition, the special perception, of a whole as consisting of members—not its division into separate parts. By the latter I mean the recognition of members as constituting a whole; I do not mean a combining of separate elements.

It is believed and, I doubt not, rightly, that in the beginnings of speech the single symbol stood for a total unanalyzed thought. Indeed survivals of this method exist at the present time. It is the basis of the cable code. It crops out in such expressions as "Pluit", in which the word performs the function of the sentence. It is recognized in "Yes" and "No," which, by reinstating previously mentioned elements of thought, attain the values of affirmative and negative statements. (See further, p. 441.)

But the difficulty of this method led to its abrogation, as the number of thoughts to be expressed grew larger. For the number of symbols which the mind can remember must be reckoned by thousands only; while the number of different thoughts which the mind may form is quite beyond reckoning. On the other hand, the number of ideas or thought-elements which the mind has thus far developed is comparatively small. Yet by co-think-

*Another view of the sentence, preferred by some, I mention only in order to discard it. According to this view I centrally announce what I conceive as an action, by the word "employs." With this employing I at the same time think of Brown as standing in the relation of actor to his own act (one of the relations covered by the phrase, "relation of subject to verb"). At the same time I am supposed to think of the employing and the Italian as standing in the relation of action to its own actee ("the relation of verb to its object"). But I believe that we actually make a short cut. Just as I hardly think all at once of A as the brother of B, and of B as the father of C, but rather of A as the uncle of C; so also I hardly think of "Brown" as related in one way with "employing," and "employing" as related in another way with the "Italian." I rather think of "Brown" as related with the "Italian;" and the relation I conceive as that of employer to employee. That is, I make over relations to suit the direct relationship required.

ing these elements, comparatively few in number, it plainly must be possible to form essentially all thoughts of which the mind is thus far capable. A method, then, which can symbolize thought-elements, is obviously available for the ultimate symbolization of thought-totals; and, as it lays the lighter and more endurable burden on memory, such symbolization of elements has been preferred. Accordingly the symbols which language uses—that is, words—are, with few exceptions, not the signs of thoughts, but the signs of thought-elements, or ideas.

Although then it may safely be admitted that, in some stage of its history, a thought exists in mind as a unit, a conscious whole, an "Anschauung," without distinct perception of its members, without recognition even that it consists of members, nevertheless, as there are practically no symbols for wholes, but only for members, it is obviously only thought-members that can be expressed. The first condition, then, of well developed speech, is the existence in mind of what such speech can express, that is, thought-members. In other words thought must be regarded by the mind as not a simple whole, but as consisting of recognized members.

The case is quite analogous to that of sense-perception. I see my horse at one moment as a somewhat vague unit. At the next I specially perceive his head, neck, body, legs and tail. But I do not feel that I have developed any lack of continuity in the structure of the animal. Suppose now that I wish to show you this horse. It is night, and my only light is that of a dark lantern. At the close range enforced by the smallness of the stable, I cannot exhibit him all at once. Accordingly I flash the light upon his head and then successively upon the other parts of his body. You do not at any moment see the animal as a whole. Yet the mental picture of him which you form, is the picture of a whole. Indeed I suppose you had this wholeness in mind at the first appearance of the head. You did not regard that head as a fragment which might or might not be followed by other fragments, which in case of their appearance you would join together. Nor did I feel that I was exhibiting fragments, which would require any union. I made a revelation of the animal, it is true, in successive installments; but each installment was given and received rather as a partial revelation than as the revelation of a part. In short we agreed that we were examining members, indeed, but members of a body whose wholeness was unimpaired.

The case of linguistic thinking is analogous. Forced by the limitations of existing linguistic methods, I regard each member of my thought with special attention; but I do not thereby break its union with other members. Indeed I do not see how I could do so, except by dropping such other members out of mind; and this would mean the destruction of my thought; for my thought is no longer my thought, if deprived of even one of its members.

Your attitude I take to be like my own. Since people talk for the purpose of expressing thoughts, you assume, as soon as I begin to speak, that what I intend to express is a thought—that is, a whole. You do not therefore feel that you are receiving fragments, which you are to join together.

I regard the sentence, therefore, not as the presenter of thought-fragments which need to be joined, but as a successive revealer of thought-members, never conceived by speaker or hearer as other than a whole. The fact that each thought-member is a member, I regard as always present in the mind, though never prominent—that is, as taken for granted.

The "life-history" of a thought expressed in words I accordingly take to be as follows: In the first of its stages it is recognized in the speaker's mind as a unit. In the second stage it is recognized as consisting of members, each of which is commonly presented by a single word. In a third stage, the co-presentation of these words as a sentential unit is matched in the speaker's mind by a synthesis or recognition that thought-members, though individually noted, still continue to constitute a whole. To the hearer the words of the sentence—coming, as they must, one after another—present, in a fourth stage, an analyzed thought; and this, in its final stage, the hearer synthesizes.

DIFFERENT ANALYSES OF THOUGHT.

It is obvious that all analyses of thought, if carried out completely, will specially recognize each member of whatever thought be analyzed; and so far all will be alike. But they may differ, even with thought of the smallest possible membership, in the perspective or relative prominence in which they put the individual thought-members.

Usual analysis reveals two elements and copula.

It is obviously possible to regard even the trio of ideas, which appears in every thought, as consisting of two members, one of

which again consists of two sub-members. Thus "*a* equals *b*" may be regarded as consisting of a subject "*a*" and a predicate "equals *b*", itself composed of two sub-members, a verb and its object. The subject and the predicate may further be distinctly recognized as co-members of a unit. This co-membership or mutual belonging is, in the traditions of Logic and Grammar, strongly emphasized—augmented, it may be, by an idea of existence—and its symbol, whether found in an "is" or conceived to be embodied in "equals", is called a copula.

This analysis, always possible, is

(*a*) not always plausible.

In "Brown struck me", I may indeed regard the "striking me" as something to be thought of in connection with Brown. But I may also, and much more naturally, regard "Brown's striking" as something to be thought of in connection with myself.

The analysis noted is

(*b*) sometimes unavailable.

In "Here is the book which you lost," to use grammatical parlance, "you" is subject of the relative clause, and "lost which" the predicate. But the structure indicated by this analysis, has no value for the speaker's purpose. The aim of the relative clause is to confine your thinking to a particular book. I invite you, therefore, to think of "book," in connection with "your losing." I do not invite you to think of "book-losing" in connection with yourself. The relative clause must accordingly be analyzed into "which" and "you lost," to make it available for my restrictive purpose. (See "A Revision of the Pronoun" Chap. IV-III-*b* full face.)

The analysis noted is

(*c*) often not made.

If you ask me to state the size of A in terms of B, I naturally answer that "A—is—equal to B". You asked for a predicate; and there you have it! But if you ask for the bulk-relation between A and B, I answer "A *equals* B". In this statement I do not intend "equals B" as a predicate of "A". If a predicate must be found, I should look for it in "equals" only, regarding A and B together, not perhaps exactly as a subject, but as that with which the predicate is associated.

It is possible then to analyze the idea-trio of thought in at least three different ways. "A equals B" may be regarded as consisting (1) of "A" and "equals B", (2) of "A equals" and "B", (3) of "A—B" and "equals". Each of these analyses is primarily bipartite. Each regards the sentence as, so to speak, binomial.

Adopted analysis reveals at least three elements.

It is possible also to recognize initially that a thought consists of three members—is tripartite—and that the corresponding sentence is trinomial. In "A equals B" such recognition, or analysis, develops three thought-members, a first term "A", a last term "B", a mid-term "equals"—a relation, that is, between the first and the last. If any one insist upon it, I admit a relation of mutual belonging between each part of this mental whole and the remainder—or between each part and every other—or simultaneously between all parts. That is, if copulas be desired, my thought, to my perception, simply bristles with them. But as mutual belonging seems to me, as said before, to be taken for granted, I content myself with the trio of terms directly revealed by my analysis. This analysis I propose to use on account of its special convenience, or rather its actual need, in the effort to interpret the sentence.

Meantime I lay some stress upon the claim that the number of elements revealed by the adopted thought-analysis will at the least be three. To support this claim, suppose the number of elements revealed to be less than three. Let "A" for instance be omitted. The remainder, namely what is expressed by "equals B", I should simply regard as not a thought. Agreement with this opinion will largely depend on what is meant by thought. But I suppose that the adherents of the subject-predicate analysis would also hold that what is expressed by "equals B" is not a thought, but a fragment of a thought. A recognition of equality is the result of a comparison; and a comparison implies two elements compared. I cannot think of an "equaling B," except as an equaling on the part of something. I must then fill the place of the absent "A" at least by an indefinite; and so soon as I do this, my mental total becomes again a thought complete, though obviously a thought of inferior value.

Equal thought-destruction would be wrought by the omission of "B" or "equals". I therefore venture to call the relation

element of thought, and also the related elements, essential—and to call their total an essential thought.

Comparative merits of different analyses.

On these I do not insist. I argue only for the right to choose the analysis adapted to my needs—a right belonging to every type of thought-investigator. In the analysis which exhibits a subject, copula and predicate, the copula is after all the mid-term, merely reduced to a constant meaning—an obvious convenience in operations involving a pair of thoughts, or more. The first and last terms of thought are moreover in Logic sometimes so made over that each may be put in the place of the other. "A equals B" is invested with the meaning expressed by "A—is—equal to B"; and this meaning is further modified into that expressed by "A—is—a B equaller". By such manipulation the sentence is made to present a thought whose first and last terms may, with proper caution, be interchanged—a great convenience in forming deductions, since what is said of one term may be said of the other. For instance, given "John eats turnips" and "A person who eats turnips presumably is hungry", if I change my thoughts to the forms expressed by "John—is—a turnip-eating person" and "A turnip-eating person—is—a presumably hungry person", the way is made easy for "John—is—a presumably hungry person," or "John is presumably hungry."

Such modifications of thought are also at times a valuable safeguard. For instance, given "John—is—walking" and "Walking—is—good exercise," if the first thought expressed be modified to suit the expression "John—is—a walking person," the temptation to false deduction is removed.

Such modifications seem to me, in the interest of deduction, to be not only justifiable, but also very much to be desired. Indeed it is Logic's business to make them. But in making them, I do not understand that Logic claims the resultant thought-forms to be what we have in mind in the ordinary use of speech. This last, however, is exactly what it is the language-student's business to discover. With what might be in mind, and even with what had better be in mind, when I use a given sentence, he has nothing to do. His business is to find out what I actually have in mind; and if he supposes that I have in mind what should not be there, it is his even more imperative duty to verify his supposition—not to argue for the presence in my mind of that which isn't there. He is the searcher for what is—not the imaginer of

what would be nice, if only it were; for otherwise he becomes the merest sentimentalist. In short, his aim is not the reformation of sentential meaning, but rather exact sentential interpretation.

Equivalence of conclusions based on different analyses.

The view of thought which regards it as consisting of subject, predicate and copula, should lead, I think, to ultimate results the same as those to be obtained from a recognition of linguistic thought as consisting of a pair of terms and their relation. For the copula itself, or the idea which the word regarded as copula stands for, is a relation—a relation, to my own mind, of little practical importance, but still a relation (a relation, at the least, of mutal belonging) between subject and predicate.* The adopted analysis, on the other hand, develops a relation of maximum importance and accordingly more tangible. This tangibility will lighten the labor of further investigation, without, as I hope, invalidating its results, even for him who may regard the particular relation which I employ, as imaginary. The conclusions more easily reached by the study of a tangible relation, will be found available, I think, for the more elusive relation expressed by the copula.

Danger of underestimating the vagueness of thought-elements.

The effort to interpret is in danger of reading into words a meaning which they do not distinctly have in ordinary usage. Indeed, the more the interpreter studies the sentence, the more certain he is to find for it values more precise than those which even he himself has in mind, in his ordinary use of speech. This result might roughly be explained by the current assumption that language reveals but a part of thought, and that part vaguely. I believe, however, that what is defective is often rather thought to be revealed, than the means of revelation. Such thought is, in one or more of its factors, commonly undeveloped. What the speaker wishes to be learned from his words is not, in many cases, what he actually thinks, but what he might think, if he took the trouble to do so.

To illustrate, when I say in ordinary conversation "John is my father," "John is honest," "John is walking," "Walking is good exercise," the meanings of "is" are so undeveloped, even to myself, that I do not fully notice the difference between them. In each case what I have in mind is little more than this, that the other terms of my proposition have something to do with each other. That is, I am conscious that they are related; but I only incipiently particularize their relation.

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*For the idea of "existence," so often alleged as the meaning of the the copula, see p. 380, note.

My mental status is roughly indicated by the children's formula: "John goes with man" or "John and man go together," etc.

If now I accept this vagueness as final, I can go no further in the study of the "is." But I do not so accept the vagueness; for more was doubtless in my mind, and more intended, than was at the outset fully apparent, even to my own observation. For suppose I put together "John is walking" and "Walking is good exercise," endeavoring to reach the deduction customary with proposition-couples of these forms. I perceive at once that I did not mean by "is," in one case, what I meant by it in the other. Indeed, as I review my illustrations with more care, I am very sure that they differ as follows: In "John is my father," the relation to which I invite your attention is essentially that of equivalence. The person distinguished by the symbol "John" is, in a merely different aspect, the person distinguished by paternal relation to myself. In "John is honest," relation is that of object to its own quality. In "John is walking," it is that of actor to his action. In "Walking is good exercise," and more distinctly in "Men are animals," it is that of species to genus or class to larger class, a relation conveniently distinguished as that of inclusion.

My initial carelessness with these relations may better be understood, perhaps, by the aid of an objective illustration. Let relations be replaced by Christmas gifts. As each relation belongs with a particular pair of terms, let each gift be intended for a particular pair of persons: for Brown and his chum a chafing-dish; for the Robinson twins a Noah's ark; for my servant and wife a five dollar gold-piece. All of these objects lie on the dining-room table. I ring for my servant and his wife; and, as they enter, I say "You will find a present on the table in the dining-room." For the moment "present" stands to me for no particular gift. At a former time I did some careful planning, and distinctly sensed the individuality of each particular gift. In the future I am likely to repeat the process. Just now, however, I am busy with other matters, and do not think of any particular object, as I utter the symbol "présent." I am all the more willing to be indefinite in my mental picturing, because I know that "present" stands for something suitable to my servant and his wife. Moreover, I am confident that my servant's sense of fitness will preclude his making any error. In short, I am indisposed to the effort of making a detailed mental picture; and, being assured that a less onerous rough-sketch is all that the occasion requires, I let it go at that. Moreover my servant, knowing my mental methods, though momentarily somewhat baffled by the numerous possibilities offered by the word "present," is confident that when occasion requires he will be able to make a right selection among them. On reaching the objects indiscriminately suggested by "present," he appreciates the unsuitableness, to himself and wife, of the chafing-dish or the Noah's ark, and pre-

sumably takes the money as what I intended. Suppose, however, that he makes a mistake and, coming to thank me, appears with the Noah's ark. I should tell him that I *meant* the money. That is, I pass beyond what in saying "present" I *did* think of, reaching what I *was able* to think of with further effort, and *intended* him to think of. And so, too, with the idea expressed by "is," it seems to me by no means, in the usual sense, indefinite or unknown, but rather, dim, because exposed to the feeble light of partial attention, and yet intended and expected to become clear in the brighter light of an attention which will be more complete when occasion requires.

While then I cannot say that the idea expressed by "is" appears in the speaker's mind in full distinctness at the moment the word is used, I believe that this idea is expected to become distinct in both his mind and that of the hearer, whenever necessary. Such an idea is obviously very different from the ordinary indefinite, which is expected not to become distinct. For instance, note the value of "somewhere" in "I somewhere heard that you have been ill."

Accordingly I make the somewhat precarious assumption that words should often be interpreted not merely by what is at the moment in the speaker's mind, but rather by what would be in his mind, if he thought more carefully—what moreover he intends to be in the hearer's mind, whenever occasion requires. In other words I regard ideas expressed as often germs, and propose to investigate them, when the need arises, in a developed stage.

For the above conclusions, independently reached, support is offered by Stout—See Analytic Psychology, ed. '96, Chap. IV, Implicit Apprehension, especially pp. 95–96.

Danger of underestimating the freedom of thought.

By this title I mean to indicate my belief that thought of the sort expressed by speech does not in every case respect the bounds set up by some psychologists. These will have it that every judgment is association of attribute with substance, or a recognition of association. For one, I should carry deference to this opinion so far as to admit that every judgment may be so remodeled as to be exactly of the indicated type—that possibly every judgment ought to be so remodeled. But that every judgment *is* of the indicated type, is quite another matter.

(a) Freedom in choice of relation.

Overlooking the wider deviations from that type (see p. 361) I note that, given "A exceeds B," I can conceive (and possibly ought to conceive) excess over B as predicate of A. That is, I can conceive of A and excess over B as in the relation of substance to its own attribute. I believe, however, that I commonly think of excess as a sequel to the

successive consciousness of A and B. My sentence is to me an abbreviated mental history, which may be more completely told as follows: First I thought of A. Then I thought of B. But while the idea of A was growing weak or waning, and that of B was growing strong or waxing, and I had them simultaneously in mind, I felt a difference named by the word "exceeds." That is, my thought consists by no means of a substance, an attribute, and their mutual belonging, but rather of two ideas (which I do not seem to take the trouble to recognize as substance, attribute, or anything else) and a bulk relation between them.

Given again the preliminary A and B, I am by no means confined to their difference in bulk. I may, for instance, be impressed by their similarity in contour, or their separation in space. That is, one pair of terms may develop different relations.

Moreover, if one or both of the terms be changed, the way is opened for an even larger number of relations. While the bulk relation of A and B can be one only (that for instance expressed in A>B) the bulk relation of A and C may be that expressed in A>C; and the relation of A and D may be that expressed in A=D.

The variety of thinkable relations being obviously very great, the variety of thoughts in whose formation they have a share must also itself be great—and that independently of further variety which may be based upon the special nature of related terms. The opportunity to establish species and even genera additional to the substance-attribute type I, however, neglect, insisting only on the existence of multiple types of relation, and therefore of thought itself.

(b) Freedom in choice of relation-aspect—proverse or reverse.

To illustrate, if I pass from a hill to the valley which lies beside it, I am conscious of a change which I call descent. Conversely, in passing between identical terminals, but in the opposite direction, I experience a change which I call ascent. Again, in passing mentally from A to B, I experience a difference which I express by excess, or say superiority. Accordingly "A>B". But, in making a thought-transit from B to A, I develop "B<A".

Now so far as there be in the physical universe aught that corresponds to the mind-sensation expressed by > or <, — that is, so far as bulk-relation exist apart from mind—it must be unaffected by any act of mine, unaffected in particular by the direction in which I make my mental transit between A and B. Compared with such a relation outside of mind, my ideas of superiority and inferiority may as well be ranked as merely different subjective impressions caused by a single objective relation seen from different points of approach—or say as different aspects of a single relation. These aspects being, so to speak,

the one the converse of the other, I call them for convenience proverse and reverse.

In a sense I have the power to choose between them. For though a mental transit from A to B will compel me to experience the relation of superiority, still I am free to choose the reverse transit, which would compel the reverse relation. Being then free to choose the direction of thought-transit, I am virtually free to choose the aspect of my relation.

This conclusion I have reached from an assumption contradictory to the claim of some psychologists, who would have it, not only that in forming a judgment I must associate substance and attribute, but also that I must associate attribute with substance—never substance with attribute. For instance, such would have it that, in mentally coupling John and honesty, I must think as indicated by "John is honest," and not begin with honesty.

Now such a claim, it seems to me, is far from being respected in actual practice. Personally I feel quite free to begin with honesty and end with John. I do not, however, expect to reach the same relation that I reached when I began with John. It is true that in dealing with John and my father I may reach the relation of identity, whichever be the direction in which I think from one to the other. But that is because the relation is not one of difference. On the other hand the relation between John and honesty is one of very obvious difference, being that of substance to its own attribute. Accordingly, when I reverse the direction of thought-transit, I expect to reverse the aspect of the relation experienced. Thinking then from honesty to John I am by no means surprised to encounter the relation of attribute to its own substance, which is precisely what I express, and most distinctly, by "Honesty characterizes John."

Moreover, active and passive voices being specially intended for the differentiated expression of proverse and reverse relations, if a second time I turn my proposition end for end, resuming the original direction of thought-transit, I obtain "John is characterized by honesty"—a sentence which I take to be the exact expression of what I mean by "John is honest."

(c) Freedom in choice of relation-phase—static or dynamic.

As so much stress will be put on the relation, and as it will be recognized in several disguises, a further suggestion may be of value. Thus, in such expressions as "Roses are red," the relation (of object to its own quality) is conceived as established and, so far as considered, permanent. In "The rose became red," the same relation is viewed as developing, as formative, as passing from non-existence to existence. In the former case, in lack of a better name, the relation may be known as static; in the latter, as dynamic. So also "to have" expresses a rela-

tion (say that of owner to property) in the static phase, while "to get" and "to acquire" express the same relation in the dynamic phase. Moreover a single word may express, on one occasion, one, and, on another, the other phase—as in "A exceeds B," which may be taken as meaning either "A *is* greater than B" or "A is *becoming* greater than B."

It is the dynamic relation which is commonly expressed by the verb of action, when attended by its object. Thus in 'A killed B" the relation of slayer to victim is considered in the formative phase—a phase which in "A was killing B" is dwelt upon or, so to speak, stretched out in temporal length. Action then may be interpreted as formative relation, thus facilitating the recognition of the general principle, that every thought of the linguistic type consists of at least two terms and their relation.

THOUGHT-ELEMENTS VERSUS THOUGHT-ATTENDANTS.

By thought-attendants, elsewhere described as instructional (See p. 431, etc.), I mean a variety of suggestions commonly offered by sentences, but forming no part of centrally intended thought. Given, for instance, "Orange exceeds lemon", I find in the verb a person and number value. But this I regard as merely helping the association of the relation with the right first term, in case the sentence, by exhibiting several possible first terms, creates an opportunity for error. I also find that "orange" and "lemon" may have case-endings which would locate the idea of each as either first or last term of thought expressed. But this idea of position in thought-structure, like the idea of association noted just before, is not a part of the thought to be constructed, but merely a guide to the proper construction of that thought. Such ideas compare with actual thought-members much as the plans and specifications of a building compare with the materials of which it is made. Accordingly in the present investigation I neglect them.

Primary or essential thought-elements.

By these I mean the terms thus far revealed (See p. 367) by thought analysis. For instance, in the thought expressed by "Orange exceeds lemon", I discover, thus far, only the idea expressed by "orange", that expressed by "lemon" and a relation of bulk-superiority expressible by "excess." As none of these can be omitted without my thought's surrender of its claim to be a thought, they may be ranked as the essential elements of the given thought.

Of other elements that may be added to that thought, I should maintain that, however useful they may be, they still do not succeed in making thought more truly thought, than it was without them. These accordingly I rank as unessential under the title

Associate thought-elements.

Such elements may be found not only in "Large oranges exceed small lemons", but also in the expression "Orange exceeded lemon". In this, besides the naming of a particular bulk-relation, "exceeded" plainly symbolizes an idea otherwise expressible by "in the past." I find moreover that, antagonistically to the passive voice, "exceeded" names the relation of superior to inferior and not the relation of inferior to superior. "Orange" too, and "lemon", may exhibit ideas of number and of sex—the latter degraded, it may be, into gender. But such ideas of time, voice, gender and number occur in all expressions that I shall examine. Being then by no means peculiar to particular expressional types, they do not aid the differentiation of these types from one another. So I discard them from all thought to be discussed, and do so with especial satisfaction, since every added detail aggravates the difficulty of investigation.

Associate of thought versus associate of idea.

By suggesting in this title that an adjunct may bear upon a total thought, I break completely with traditions commonly accepted. I have been taught to believe that, once the skeleton of a thought to be formed is established in the mind—a skeleton consisting, at the most, of three parts only—any addition thereto must be an addition to a single one of those parts. I am however forced, with doubtless many others (e. g. Paul and Sweet), to believe that some ideas are added to the whole of the skeleton at once.

The nature of these ideas, and the argument in favor of their annexation to the total thought, I take up later. Meantime, to change my figure, let it be enough to note that my attention has been, up to date, confined to trowsers, coat and cap—the garment, each, of part only of my body. I must now extend my mental vision to my cloak, with which I may invest my body all at once.

THOUGHT-ASSOCIATES.

(Thought-reality.)

Examining the thought expressed by "Orange exceeds lemon," I find that it is real. But, in saying this, I must use the utmost care, to avoid misunderstanding. I mean, and only mean, that the thought is actually formed in my mind. It goes also without saying that each element of the thought, each idea thereof, is also in my mind. In other words I merely hold with others, that even intellectual phenomena are facts. As reality thus defined is characteristic of all our thoughts and all thought-elements, it may be neglected in their comparative study.*

Thought-truth.

By truth I mean accordance, so far as may be, with reality external to the momentary action of the mind—a being-matched by external reality.**

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*It is true that reality might be conceived by the mind along with one thought or a part thereof, and not with another thought or any of its parts. But I do not find that such is the fact. For instance, when I say that "Orange exceeds lemon," I do not tell myself that thinking of an orange is with me a real occurrence. I draw no contrast between my real thinking of the orange, and an unreal thinking of an apple—or anything else of which I simply am not thinking.

**It is possible of course to associate such truth with an individual thought-*member*—that is, to make it the adjunct of an *idea*. For instance, given again the expression "Orange exceeds lemon," I feel that my idea of the greater fruit is fairly accordant with an existing external object, as is also my idea of the less. How far the idea of excess is matched by aught that outlies thought, is debatable. But as much as this, at least, is obvious: that the idea of excess does vary with variations in external data. It may then be asumed that this idea is as true as it can be to that which is external. Each idea, that is each member of my thought, possesses then its maximum degree of truth attainable by mind.

Such excellence of detail does not, however, mainly interest me. As I taste my soup, I care not greatly for the nature of its individual elements. What I desire is that the soup itself be good; and if in this desire I am disappointed, I shall not be comforted by any eulogizing of the soup materials. Toward thought my behavior is quite analagous. For instance, the idea expressed by "Booth" is matched by a counter-

To illustrate, suppose that I have made a mental transit between the ideas expressed by A and B, and that I have further experienced a mind-sensation expressible by the word "excess." These three elements of consciousness together form a unit; and to this unit each element is indispensable. Regarded thus only, all elements rank as equal in importance. That they may, from other points of view, appear unequal in importance, has been conceded. (See the preceding note.) In the interest of simplicity, I elect to consider only the obviously possible case of parity.

Suppose me further to feel that the mental status just described is matched in the outer world by two objects and their bulk-relation. In other words I regard my whole *thought* as true. If now I wish to add to my thought this idea of truth, forming thereby a thought of greater complexity, I may say that "A truly exceeds B."

Now most grammarians will tell me, I suppose, that "truly" is an adverb—that is, that the idea of truth is treated as an

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part in physical reality, or, in other words, is true; so also are the ideas expressed by "killed" and "Garfield." It is even true that Booth killed; and a killing of Garfield actually happened. But from all these truths of detail I derive but scanty satisfaction; indeed I heed them little in the presence of the total "Booth killed Garfield." Truth, in short, as an *idea*-adjunct, is commonly neglected, to the point at least of failing to be a part of what I mean to say.

A peculiar modification of truth is, however, very commonly associated with the individual thought-member or idea. To illustrate, if you ask me what is the relation between A and B, I answer, emphasizing the relation, "A *exceeds* B;" and to this idea of excess I specially attach an idea, roughly speaking, of truth. I mean, however, this time something more than that the idea of excess is matched, outside of my thought, by what is real. What this something is, I can seek to better advantage in a more objective illustration. Let it then be conceded that fire and gunpowder, being assembled, produce, by means entirely unknown to me, an explosion. Reasoning along the well-known psychological highway, I conceive a faculty of explosion-causing, or say the quality of explosiveness. Strictly speaking, I ought to predicate this explosiveness of the combination fire and gunpowder. But in actual practice I use the expression "Powder is explosive." This explosiveness is not, however, on a par with other qualities of powder, for instance its blackness. It is black unaidedly. It is explosive only with the aid of fire. It is not productive of explosion peculiar to itself. It is co-productive, with fire, of an explosion peculiar to powder and fire

attribute of the excess. Again, if I leave the idea of truth without a special expression, I suppose it would be held that, so far as truth is still a part of my meaning, it still attaches itself to the idea of excess. That is, in "A exceeds B" (Conf. "A does not exceed B") any truth regarded as part of what I mean, is an incorporated limiter of "exceeds"—a part of the total meaning of "exceeds" and limiter of another part of that meaning, namely the idea of excess alone.

But, as I have argued above (See the preceding note) any truth proper, which is associable with a single idea, will be that single idea's being-matched by a single element of external reality; with truth of this sort, however, I do not think my sentence deals. On the other hand, the truth of my total thought, with which my sentence does deal, cannot, if I have rightly argued, appear as the attribute of a particular thought-member, except in the modified form of rightness, or co-productiveness (with other members) of true thought. Such modified truth, how-

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combined. So also when I say that "A *exceeds* B" or, more laboriously, "The excess of A over B is true," I really mean that the excess is co-productive, with A and B, of a truth peculiar to the combination "A exceeds B."

Now in the thought before me A and B are postulates, accepted without approval, without a mental vote—the charter members of an idea society. "Exceeds" on the other hand is offered as a later candidate. Truth being the aim of the society, it is important that the prospective new member co-operate effectively with the charter members, in truth-production. The intrinsic merit of the candidate is of less importance than his suitableness to members already enrolled. Accordingly, in the sentence "A *exceeds* B," I should say that what I associate with excess is not precisely the idea of *truth*, but rather an idea of *suitableness to A and B in true-thought production*—or, in a word, *rightness*.

By similar reasoning I should argue that, if in the same expression A be emphasized (or B), an idea of rightness is associated with A (or B). It appears accordingly that any member of that idea trio which constitutes an essential thought, may be regarded as an accession to the others, and further also as suitable to those others, in true-thought production—in other words as right—in other words as, very roughly speaking, true. I have accordingly carried one step further the thought-forms presented on pages 361–362.

All of these thought-forms I propose from now on to neglect in favor of another, not that they are uncommon or inferior, but merely because they promise no addition to what may be gained from the examination of that other, which has the advantage of being simpler.

ever, I dismiss because, so far as I know myself, I do not at present have it in mind. I am not just now thinking that, in the production of true thought, "exceeds" is a right addition to A—B, any more than I am thinking that A is a right addition to "exceeds B," or B is a right addition to "A exceeds." That is, I am not dealing with "A *exceeds* B," "*A* exceeds B" or "A exceeds *B*." I am dealing with the unemphasized "A exceeds B."* In this last expression I am merely thinking that what I express is true, regarded as a whole; and to this truth of total thought I wish to confine attention, because it has the advantage of maximum simplicity.

That I do thus actually think of truth as bearing on total thought, is, in some cases, apparently beyond a doubt. Suppose, for instance, that you say "The air is very cold," and that to this I answer "That is true." My "That" revives before our minds the total thought (consisting of the air, the extreme coldness and the qualitative relation between them) which you expressed, but without a recognition of any particular member. It is accordingly in this case impossible that what we think of as true be any single member of thought. It must be then that what we think of as true is a total thought.

The mental feat which we perform in this case I seem to myself to perform again, when I say that "A truly exceeds B," or when I incorporate the idea of truth in the meaning of "exceeds" and confine myself to saying "A exceeds B." I confess, however, that thus far I see no means of proving such to be my mental act, and therefore must appeal, in support of my opinion, to the self-introspection of others.

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*I am aware that in actual practice a wholly unemphasized sentence is rare, the tendency being to put a vocal stress upon the final word, even when there is no thought-dominance of the corresponding idea. I suspect that this tendency is initiated by the habit of giving the final position to the word for the dominant idea. Conversely the final word is commonly a dominant and properly emphatic word. By the unreflecting, what is common is made universal. At the same time the customary fall (in pitch) of the voice at the sentence end, is rather advantageously offset by an increased loudness, the danger of a failure to be heard being thus avoided. Be the reason what it may, as a matter of fact the final word is often emphasized, even to the complete neglect of the rational emphasis. E. G.: "I am no longer a young *man*." "If thy father and thy mother forsake thee, the Lord will take thee *up*" (a Sunday-school reminiscence).

The truth which is conceived of thought can not, of course, be absolute. It is, after all, the mind's impression of agreement between a picture which it forms, and an external reality, which may be posed as the original of the picture. Now this original itself is far from being certainly known. What appears to be reality may not deserve to do so. In such a case what I regard as matched by external reality will merely be matched by what wrongly seems to me to be reality. Bearing in mind the possibility of such a mistake, I re-define the truth of thought as a being-matched by supposed reality outside of thought.

Such truth is all that language contemplates. No doubt, in thinking, we desire and strive to be correct; but in speaking we endeavor only to reveal what actually is in our minds, correct or incorrect. The lie, as not a use of speech, but plainly an abuse, may be set aside as utterly non-linguistic. The aim of speech is communication—a begetting in another mind of a counterpart to what is in one's own—a reproduction of the momentary mental self. In the case of a lie the should-be parent thought is childless, but charged with bastard offspring. The liar is mentally a self-made cuckold. On the other hand, the issue of error is legitimate. The statement unintentionally false is to the full degree linguistic. Brother Jasper's "The sun do move" is as truly and properly language as any utterance more acceptable to science. Truth, then, so far as it concerns the language student, is subjective truth. Accordingly, in a sense more extended than that employed on p. 360, it may be said that sentences deal with thought alone—never directly with extra-mental fact.*

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*It is obvious that my "truth" of thought is merely a substitute for that element of "existence," which is often regarded as part of what is meant by an affirmative assertion. Thus "The rose is red" is commonly paraphrased by "The rose exists red," "The red rose exists" or "There exists such a thing as a red rose."

In such an interpretation, it seems to me that existence is synonymous with reality, being thinkable either of my thought itself (or a part thereof) or of that external status of which my thought is the internal correlative. Now the reality of my own mental act appears to me unimportant, for reasons given above. I can hardly feel it worth my while to vouch for it, that I am actually thinking the whole or any part of my thought. If then I do vouch for any reality, it seems to me it must be the reality of that to which my thought is correlated, namely some fragment of an outer universe or status. Accordingly the "exist-

Thought-untruth.

By untruth I mean a failure to be matched, or a being-unmatched, by external reality.** To argue that untruth takes its place in mental structure as the attribute of a total thought regarded as a unit, and to contend that untruth is quite as subjective as truth, would be an essential repeating of pp. 377–380.

MENTAL REACTIONS ON THOUGHT-ASSOCIATES.

Such mind-activity as language aims to reveal contains an element which thus far has not been considered. To illustrate,

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ence" which I am supposed to incorporate in "The rose is red" would seem to be a portion of the outer-world's reality. That is, my sentence would be regarded as declaring that, in the outer world, the mate to what I think of exists or is. Personally, however, I construe my sentence as declaring that what I think of is matched or mated in the outer world.

The difference between the two I admit to have its analogy with that of tweedle-dum and tweedle-dee. Yet, as the mental state presumably copies the outer world, if that which language deals with be the copy, it would seem more natural to say "The copy is that of a real original, or is matched by such an original," than to say "The original of the copy is real, or exists." My special reason for preferring the idea of truth to that of existence is, however, the possibility of greater brevity, and at the same time the ability to distinguish readily between the reality (= mere actual occcurrence in mind) of thought and that agreement with the outer world which I mean by truth. As I seem to take account of all thought-elements or adjuncts considered by the supporters of the "existence" theory, in a merely different perspective, I hope that even to those supporters the conclusions reached will be available.

In all the above I am naturally not to be understood as denying that "is" occasionally has the meaning of "exists" or "is existent," as in "Whatever *is* is right."

**It is possible of course to associate untruth with an individual thought-*member*—that is, to make it the adjunct of an *idea*. With idea-untruth, I should however argue, the sentence deals as little as with idea-truth.

To the modification of idea-truth, described on p. 377 (note) and known as rightness, there corresponds a modified idea-untruth, a wrongness, an unsuitableness to fellow terms in true-thought production. This wrongness, however, I neglect for reasons similar to those which seemed to justify the neglect of rightness.

suppose that, as you sit in my study, your attention is caught by a painting, on which you invite my comment. If I should say "That painting is a portrait," you would understand me to vouch for its being matched by a real person. If on the other hand I should say "(Some claim) the painting to be a portrait," you would understand me to do all that I did before, except that I should no longer *vouch* for the matching. That is, you would understand that I have merely thought of the matching—that, so to speak, I have not felt it.

So also, if I should say "My son to lead his class," you would understand that a mental picture of my son's leading his class is in my mental visual field, along with a being-matched by fact —or, in other words, along with truth (Compare "My son *not* to lead his class"); but this truth again I do not feel; I only think of it. I put before you, so to speak, the elements of a mental experiment; but what ultimately happens, or say the reaction, I do not exhibit. Now it seems to me that the reaction is precisely what you most of all would wish to know. If I put a slice of lemon in my mouth, I shall hardly thereby greatly interest you. But if you can learn how this experiment affects me, you may find it worth your while to do so. Again, if from my words you merely know that certain ideas assemble in my mind, your knowledge has for you but little value. But if you learn the effect which they produce upon me, you may feel repaid for your share of the effort incident to thought-communication. Given then the truth or the untruth of "My son's leading his class"—or given, say, "My son to lead his class" or "My son not to lead his class"—if you can learn that I fear or hope for either—that I like or dislike, desire, regret, expect, believe or disbelieve the one or the other—you may esteem such learning worth your effort.

Now any one of the reactions noted—and others also—may be expressed by speech. But most of them require the aid of special words. For instance, given "My son to lead his class," if I wish you understand that my reaction is what is known as hope, or expectation, I am obliged to say that "I hope, or expect, my son to lead his class." That is, the reaction requires a special word for its expression.

Suppose however that, given "My son to lead his class," my reaction is belief. In this case I merely say that "My son leads his class." That is, the word "leads" expresses all that was

expressed by "to lead," and also all that might be expressed by "I believe" (or say "I know").

It is obvious that, by further loading such a word as "leads," a sentence might, without increasing its bulk, be made to express an even larger volume of thought. Indeed, as I believe, it is by exactly such an increase of the single word's expressional burden, that the question-forms of speech have been developed. To me then obviously the study of interrogative expressions is—to imitate the agriculturalist's "intensive farming"—a study of intensive symbolism.

Now symbolism of this order has, in question-forms, attained perhaps its highest development. It can best be understood after examining those other grades of symbolism, of which it forms the climax. Such examination should be based, I think, upon a comparative study of thoughts expressed, to which accordingly I pass in the following chapter.

CHAPTER II.

INTERROGATIVE AND OTHER THOUGHT COMPARED.

Each kind of thought may vary in extension.

By this I mean not only that, in general, thoughts have different numbers of constituent ideas, but also, in particular, that every kind or grade of thought to be examined may so vary without becoming a thought of another kind. That is, I wish to emphasize the distinction between mere difference in size and difference in kind. To illustrate, "Brown is certainly very honest" stands for, so to speak, a bigger thought than "Brown is honest;" but, for my present purpose, these two thoughts will rank as of one kind. On the other hand the thoughts expressed by "Brown is honest" and "Is Brown honest?" might seem, to a hasty view, to differ little, if at all, in size; but I shall rank them as very different in kind.

Each kind of thought examined in its minimal form.

By this I mean that, for the sake of clearness and convenience, I shall deal with thoughts containing only the ideas required to make each one of them a thought of a particular kind. For instance, "Brown is honest" will suit my purposes better than "My friend Brown is undoubtedly a very honest gentleman."

The kinds of thought to be examined under the following A, B, C and D, may be regarded as interpreting respectively the kinds of expression illustrated in connection with those letters on p. 354.

A. THE CONCEPTION *(expressed by a suggestion).*

By this I mean the lowest grade of thought—such thought as would be thought no longer, if deprived of any element. This I offer to attention merely as a convenient background on which to project the judgment.

Conceptions are expressed by what may be roughly called suggestive phrases. In illustration all needs will be met by the infinitive phrase, which alone accordingly will be considered. For the sake of saving labor, I select an infinitive phrase which offers a pair of terms and a relation named with maximum distinctness; and I choose a relation as simple and tangible as may be. I omit the "article" for the sake of brevity, and treat the English infinitive as a single word. It will express in my illustrations no more or less than what is expressed by the one-word infinitives of other languages. Indeed the "to" may be regarded as the infinitive inflection, merely isolated and prepositive.

My immediate purpose, stated from the sentence-student's point of view, is to determine how much meaning there may be in a typical suggestive phrase, for instance, "Orange to exceed lemon." Next I strive to find what further meaning lies in an expression assertive, but otherwise equivalent to the suggestive, for instance, "Orange exceeds lemon." That is, a sort of subtraction is expected to reveal, as a remainder, the distinctive assertive element of meaning, or in other words the element whose presence makes a judgment such.

Its essential content.

This I find to be a duo of ideas, and their relation. For instance, in the thought expressed by "Orange to exceed lemon," I find an idea of the first named fruit, an idea of the last named fruit, and a bulk-relation between them. I observe that, if any one of this idea-trio were omitted, the remainder would not constitute an idea-total worthy in my opinion to be ranked as thought. I also observe that, while other ideas might be added with advantage, their presence would not make the total a whit more worthy to rank as a thought of the lowest grade—that is, as a conception.

Its associate truth or untruth.

Examining further, I find in the conception an adjunctive idea of truth or untruth, put as an attribute of a total which consists of two ideas and their relation. To illustrate, I offer the two expressions:

(1) "Lemon to exceed orange," and

(2) "Lemon not to exceed orange."

I cannot admit, and shall elsewhere antagonize, the opinion that "not to exceed" is meant to call up the idea of equality or in-

feriority, one or both, or any other substitute for the idea of excess. For the moment it may be enough to remark that, in the expression "Lemon doesn't exceed orange," the inclination which the enclitic "n't" exhibits towards its neighbor "does," or say its aversion shown to "exceed," affords some indication that the mind does not associate the negative with the excess. Indeed, were it to do so, the strictly proper word would not be "not," but "non."

I regard the "not" as suggesting solely the idea of untruth. Thus construed, expression (2) reveals a thought attended by the idea of its untruth. The obvious antagonism of one thought to the other strongly intimates that expression (1) should be taken as standing for a thought attended by its truth.*

This idea of truth, or untruth, I expect to find in every thought to be examined. I have, however, given it somewhat careful attention, because it seems to me that, without it, thought of greater complexity cannot thoroughly be understood.

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*I admit that (1) might sometimes better be interpreted as not suggesting either truth or untruth—sometimes, again, as calling up to mind the categorical idea of truth-or-untruth. With such occasions however I am not dealing. In "I believe lemon to exceed orange", that which I believe is, as it seems to me, the truth of my thought—just as what I believe, in saying "I believe lemon not to exceed orange", is the untruth of my thought. It is thus and thus only that I elect to construe the expression "Lemon to exceed orange". That is, of thoughts which might be indicated by it, I choose that one which is ready for the accession of my belief. In that one accordingly I find the adjunctive idea of thought-truth.

This idea of truth is however easily overlooked, for the following reason. Affirmative expressions are, in linguistic practice, much more common than negative. The truth which ordinarily attends a thought, becomes a matter of course, and easily fails to be noted. Were you to ask me what I wish you to think of when I utter (1), I should be very apt to answer: "the relation between lemon and orange". But suppose you repeat the question with (2). I must now put in the idea of untruth, and answer: "the untruth of the relation, etc." If now you repeat your question with (1), I shall answer: "*the truth* of the relation, etc." That is, I am so used to the idea of truth, that I ordinarily overlook it. But if you sharpen my attention by directing it first to the untruth, which I do not intend, I become aware, and keenly, of the truth which I do intend.

Its distinctive.

The idea of truth which I seem to find in the conception when it is not negative, is far from being an endorsement. I meet the thought arising in my mind, as the bank-official meets the bank-note submitted to his expert judgment. He may be asked to decide upon its genuineness; or, on the contrary, he may be asked to decide upon its spuriousness. The idea of the note will accordingly be attended in his mind by an idea of either genuineness or spuriousness—say the idea of genuineness. But this attendant idea is merely the aspect in which the idea of the note is offered. It does not predetermine ultimate opinion. And so it is with the truth which forms a part of what is expressed by "Lemon to exceed orange." Thinking of such truth does not commit me. I still am free to reject (or accept) this truth, precisely as I still am free to reject (or accept) the untruth which forms a part of what is expressel by "Lemon not to exceed orange." That such is the fact, I think appears in the expression "I disbelieve the lemon to exceed the orange," in which I reject what seems to be presented in the aspect of truth—and in "I disbelieve the lemon not to exceed the orange," in which I reject what is obviously presented in the aspect of untruth. The presence then of the idea of truth, as thus far noted, is far from implying that anything *is* true; it only implies a preference to regard a thought in its possibility of being true, rather than in its possibility of being untrue. Conversely the presence of the idea of untruth implies only a preference to regard a thought in the possibility of being untrue.

The significance of my examination is less in what I have found, than in what I have not found. In particular I have not found any personal endorsement of the conception—its truth or its untruth. I have found, in other words, no element of belief. As I expect to find this element in other forms of thought to be examined, I make the provisory claim, that the distinctive of the conception is the absence of belief.

As you are likely to decide on the validity of any conception I reveal, you might prefer me to pose it unattended by ideas of truth or untruth, leaving you to form the verdict "That is true" or "That is untrue." But in linguistic practice I disregard such preference, and submit my thought in the aspect of truth or untruth, inviting the verdict "I accept that" or "I reject that." Offering however no verdict of my own, I also do not

bias yours. My conception is merely a preliminary datum, a theme, a topic. Had you asked me "Of what shall we think?", I might have answered "Lemons." In precisely the same spirit I might answer "The truth (or, it may be, the untruth) of lemon to exceed orange." The conception then is far from being a verdict, or say a judgment. It is merely that upon which a judgment may be formed; or perhaps it would be better to say: it is a mere beginning, which will become a judgment when completed by an element of acceptance, endorsement, or say belief. Or, to change my figure, the members of a judgment are assembled; but the breath of life is not yet in them.

B. THE ORDINARY JUDGMENT *(expressed by a statement).*

Its essential content.

The forming of a judgment is commonly held to be, or at least to contain, a mental act of knowing. But I prefer to follow the hint, confessedly unreliable, offered by language-history. Looking backward, I find that the primary meaning of "sententia" was "an opinion." The sentence might then be defined as an opinion or, more exactly, the expression of an opinion. Since what is expressed by a sentence is commonly also called a judgment, the hint is given to regard all judgments as opinions; and this it seems to me is safer than to think of them as knowledge. For what is supposed to be knowledge, in the ordinary sense, is often found to be no knowledge.

The word opinion itself is not however fully adequate. It names a mental status as much too weak, as knowledge is too strong. I prefer as a rule the word belief, by which I mean the act of knowing, but without distinction between knowing rightly and knowing wrongly, the latter being an extra-linguistic accident. Indeed I expect to use "to-believe" and "to-know" as synonymous, choosing the former when greater distinctness is required, and preferring the latter when its greater conventionality favors the momentary need. Accordingly what is expressed by a sentence, in other words a judgment, I regard as consisting essentially of belief in a conception.

I neglect moreover unbelief, in the sense of failure to reach belief. I also at present pass over disbelief—an embarrassing quasi-synonym for belief in the untruth of thought. It is well

enough, no doubt, to say that (1) "Orange exceeds lemon" expresses belief, and that (2) "Lemon not exceeds orange" expresses disbelief. But when I strive to differentiate expression (2) from (3) "Lemon not to exceed orange," I find myself in trouble. For, though the thought expressed in (3) no doubt may be distinguished adequately from the thought expressed in (1) and (2) by calling it a conception, (3) should further be distinguished from (4) "Orange to exceed lemon" by calling the thought of (3)—I know not what—perhaps a *dis*conception. But the word is lacking; and the idea which it indicates is unfamiliar. Again, for disbelief I shall find no approximately synonymous *dis*knowledge. I shall accordingly work to better advantage by confining myself, so far as possible, to conceptions attended now by truth and now by untruth, and to judgments containing belief in one or the other.*

Its distinctive.

To make this obvious, I write, the one above the other, a sentence or expression of a judgment, and a suggestive phrase or expression of a conception—both of the essential type—both containing, that is, only the ideas needed to make them, one a conception, the other a judgment. Accordingly

*In such expressions as "I doubt", "I do not believe", "I believe", etc., the mental act of doubting or believing is itself conceived as true or untrue, and a secondary belief is brought to bear on this truth or untruth, as is clearly indicated by the comparison of such expressions with "me to doubt," "me not to doubt", etc. Such expressions may however be discarded, attention being confined to the briefer sentential forms in which belief, when part of what is meant, is left without any special word to express it, or is in other words incorporated in the meaning of the verb, as in "Orange exceeds lemon."

The presence, in every judgment, of the speaker's belief may vindicate the sentence "Seeing that it rains, a walk will not be pleasant". He who cannot tolerate the "seeing that" as a subconscious synonym of "since"—he who feels that something there must be, to which the adjunctive "seeing" may cling—will find this something in the incorporated "I" of assertion; for every original assertion is first-personal, just as every (directly) quoted assertion is third-personal—or sometimes second-personal. So, too, in "Seeing it rains, don't go," the purist may choose between "I, who am aware of the rain, wish you not to go." and "I wish you, who are aware of the rain, not to go.", or even associate the seeing with both "I" and "you."

(1) "Orange exceeds lemon", and
(2) "Orange to exceed lemon."

Interpreting these as indicating
(1) My belief in a conception, and
(2) a conception (and nothing more),

I, so to speak, subtract the lower from the upper. I thus obtain a remainder of belief, which was part of (1) but not a part of (2). Pending further examination, I postulate that, as the distinctive of conception was, so to put it, the belief which it does not have, per contra the distinctive of a judgment is the belief which it has.

General nature of belief.

Of this a working idea may be reached, I think, most easily through disbelief; and both will be appreciated better after an objective illustration. Suppose then that, in my walk, as I am just about to set upon the ground my leading foot, I see beneath it a rattlesnake. The somewhat energetic withdrawal of foot—and general self—I can indicate perhaps to best advantage by the word recoil. But for the opposite of this withdrawal, which I also wish to consider, I can not find an equally effective word. Such opposite action I seem to conceive with sufficient clearness; indeed I find it picturesquely detailed, as I read in the gospel of St. Luke the father's reception of the homing prodigal. "His father saw him and had compassion and ran and fell on his neck and kissed him." Something of this sort I wish to express by the word *ac*currence, that is, an eager running toward what is attractive—antagonistic to an equally eager running away from what is repulsive.

In the field of thought, belief and disbelief impress me as closey analogous to these actions of the body. Speaking very roughly, if you set before my mental vision the thought expressed by "Men are vegetables," I recoil from it. I do not care at this moment to investigate the ground of this recoil, aesthetic, ethical, rational or any other; enough, in general, that I repel or reject the thought—that I disapprove it or dissent from it—that in particular I disbelieve it. If on the other hand you put before my mind the thought expressed by "Men are animals," I *ac*cur to it; I embrace or adopt it; I approve it or assent to it—more particularly I believe it.

That belief is more than I have indicated—that it is attended by a feeling that it is inevitable, that others share or ought to share it, that it is a proper and even necessary corollary of the existing order of things—I admit, but do not think it necessary to consider for the present purpose.

Linguistic neglect of disbelief.

Of the two phenomena, belief is the recognition of agreement or harmony between thought and fact, between self and the outer world, or better perhaps between the special self of the moment and the general, permanent self. Disbelief is the recognition of discord. Belief is satisfaction. Disbelief is dissatisfaction. The former is the more agreeable—the more human. In Goethe's Faust the Devil is objection personified—"der Geist der stets verneint." Belief is success; disbelief is failure—reason in itself enough for the linguistic predominance of expressions for belief. Indeed, for the sake, it may be, of being able to believe, we change to a believable form that even which we disbelieve.

To show this, I note that, in my objective illustration, the aim of recoil is strictly to be far from the rattlesnake. But the act of recoil incidentally brings me nearer to another object—say a honeysuckle now in all its bloom and fragrance. It is not true that my jump with might and main was prompted by a longing to be near that object. True it is, however, that I did most energetically reach that object. I may say with perfect adherence to fact that, not liking the snake, I changed my course, approaching something else that I like better.

So also when there looms up in my mental path a thought which I cannot approve, instead of disapproving it I can approve something else. Instead of disbelieving it, I can believe its untruth. Accordingly, if you say that "Men are vegetables," exhibiting, as I take it, your belief in *the truth of men's being vegetables,* instead of taking sides against the thought which you oblige me to think, and saying that "I disbelieve it," I say "Men are not vegetables," meaning that I believe *the untruth of men's being vegetables,* thus siding with what I think of, but thinking now of something different from that of which I was initially obliged to think.

Such considerations have by no means cogency enough to explain complete neglect of disbelief, although they seem to me

sufficient to occasion a preponderating inclination toward belief. But if one only of the two, belief or disbelief, could be expressed by speech, considerations of the sort described would seem to me sufficient to determine choice. Now just that "if" is realized in all expressions taken up in this investigation. In these there is no separate symbol for belief or disbelief. Whichever I experience must be incorporated in the meaning of my verb. For instance, given "Orange to exceed lemon," all that I do to express belief is to substitute the word "exceeds." If now I wish instead to incorporate in the verb my disbelief, I need a form analogous to "exceeds," but meaning "I disbelieve . . . to exceed . . . ." But such a word I do not find. I might indeed require the form "exceeds" to do double duty, now for belief and now for disbelief. But if "exceeds" should sometimes mean "I believe to exceed," and sometimes "I disbelieve to exceed," my hearer would be hopelessly confused; the aim of speech would be completely thwarted. By one of those two meanings I must then unswervingly abide. Accordingly, from what is meant by words of the assertive type, linguistic usage utterly excludes the idea of disbelief, admitting only belief, which however has its election between truth, which commonly is not expressed by any special word, and untruth, which is specially expressed by such a word as "not."

On what belief bears.

The main importance of this topic appears in the study of negative expressions. In them indeed the bearing of belief may be most surely and most easily determined. At present I shall exhibit this bearing merely as indicated by introspection.

Belief, as it appears in language, is an adhesion to one of two alternatives, truth or untruth. Neglecting, as before, the individual thought-member, and spreading attention over the total thought, I feel that, whatever be my thought, it is either true or untrue. With one of these possibilities, truth or untruth, I may ally myself, but not with both. "No man can serve two masters . . . . he will hold fast to the one and despise the other."

To this truth then (or untruth) it is, that I add my belief, procedure being somewhat as may be indicated by answers to questions: Q. "What is your thought?" A. "Orange to exceed lemon." Q. "In which aspect do you regard this thought

—as true or untrue?" A. "As true." Q. "Do you believe this truth?" A. "Yes."

Scope of belief.

By this I mean the extent of that to which belief applies, there being opportunity for variation of that extent, in the case of general or multiple propositions. Thus the general thought expressed by "Lemons to exceed oranges" may be regarded as a group of individual thoughts, consisting of "The lemon *a* to exceed the orange *f*," "The lemon *a* to exceed the orange *g*," "The lemon *b* to exceed the orange *h*," etc. Now when I say that "Lemons occasionally exceed oranges," I mean to indicate that some only of these individual thoughts are true.

If I said that "Some lemons exceed oranges," I should obviously be cutting down the number of lemons available in my multiple thought. If I said "Lemons exceed some oranges," I should do the same by the oranges. In saying "Lemons occasionally exceed oranges," it might be that I should similarly cut down the number of lemon-orange relations to be thought of. Each individual thought, however, being associable with its own respective idea of truth (or untruth), it seems to me that what I have cut down is rather the total of these truths. That is, among the ideas associated with my individual thoughts, I reckon some truths (as also some untruths). Or, changing perspective, I may say that the associated truth is occasional. That is, the occasionalness, or variation from universalness, belongs to the truth of my multiple thought.

So far as I know myself, it is thus that I do my thinking. But on this I do not insist, my contention being merely that either the thought conceived as true, or the truth conceived of that thought, may vary in extension. With a personal preference however for the latter, I add the following illustrations: "That lemons exceed oranges I believe to be true in actual cases (when the lemons are very large), true in possible cases (if the lemons be very large), true in impossible cases (if the lemons be grape-fruits), true in all cases, many cases, some cases, few cases, no cases."

My immediate purpose in presenting this variation in the scope of belief, is to use it as a back-ground on which to project

Intensity of belief.

While conceding that, as an initial mental act, belief is commonly subject to great variation, I claim that, in linguistic expressions of the type considered, the intensity of belief does not vary. To illustrate, suppose a cube and a sphere of approximately equal bulk; and suppose I find it hard to determine whether they be equal or not and, if not, which is the larger. Suppose that, on the whole I incline to regard the cube as greater than the sphere, but am still unwilling to risk the assertion: "Cube exceeds sphere."

As I have not reached a fully developed belief, it would be most rational for me to renounce all dealing with such belief, and to seek an expression for my actual mental status. This I might describe as a half, quarter or thirty-seven per cent. belief, an opinion, a doubt, a suspicion. But all of these require special indication and in linguistic practice become in turn the theme of full belief itself. Thus, in the expression "I suppose C to exceed S," what is centrally announced as believed to be true is the supposing, and not the excess, etc. That is, the full expression of my thought would be: "I believe in the truth of my supposing—C to be greater than S." And this belief, of course, is complete.

With an expression so obtrusive of oneself, the sentence is however by no means always satisfied. It seeks a form apparently more self-effacing or impersonal—a parallel to that afforded by "C *exceeds* S." In this expression a full belief and a believing self are indicated by a trifling modification of the relation word. (Conf. "C *to exceed* S.") That is, myself and my belief are part of what is meant by "exceeds." I should like very much to express my incomplete belief in the same way. But obviously, if what I incorporate in my verb (by its trifling modification) be sometimes complete belief and sometimes belief that is incomplete, I shall fall into hopless ambiguity. In some way the incomplete belief must be plainly indicated. Such indication, as noted above, may be accomplished by a special word for incomplete belief (e. g., "suppose") or by the ordinary word for belief plus a word of description (e. g., "partly believe"). If neither expedient be adopted, it remains possible to use a describer or modifier, understood to bear on the belief (which is incorporated in the verb, but otherwise unexpressed); e. g., instead of "C exceeds S" I might say "Partly C exceeds S," meaning that what is partial

is the belief in C's excess over S—a belief incorporated in the meaning of "exceeds." This possibility however we plainly do not utilize.

There seems then to be no further available expedient except (renouncing the modification of belief itself) to modify that on which belief is operative—either the thought conceived as true (or untrue) or the truth (or untruth) conceived of that thought.

Of the former expedient language does not, to my knowledge, avail itself. To illustrate, believing incompletely that "C exceeds S," I do not say "(I believe it to be true that) an incomplete C exceeds S," "C exceeds an incomplete S," or "C exceeds incompletely S." That is, I do not make the incompleteness the adjunct of any individual thought-element. Also I do not say "(I believe it to be true that) incompletely C exceeds S." That is, I do not make the incompleteness the adjunct of the total thought.

There remains the expedient of regarding the truth itself as incomplete or partial. To this it will be objected that truth cannot be partial—that there is no intermediate between truth and untruth. To this objection, founded on unquestionable fact, I answer that the impossibility of an intermediate is no bar to its conception by the mind.* Truth itself and untruth, and even reality, do not, as I take it, occur outside of mind. The mind creates them. The creation of partial truth would seem as feasible as the creation of truth complete (or untruth).

Partial truth is variously and ambiguously expressed by probability, possibility, likelihood, etc. These words I am using now without attendant idea of futurity. By what is probable I do not mean what I expect to happen in the future, nor what I expect to be shown to have happened now or in the past. I mean that which, regarded as of the present only, I really approximate to believing—that which, figuratively speaking, I believe to be approximately or partially true. That is, I regard the probable, not as completely true or untrue, but as lying somewhere in a quite imaginary region between the two. In saying "C probably exceeds S" I am, without question, really in some phase of partial belief. But in using the linguistic mechanism, I remodel my mental status into a belief in the partial truth of

*Students of French Grammar have accomplished the equally difficult feat of conceiving "ne—pas" as two semi-negatives, forming together one complete negative.

my thought. Partial truth, in other words, under the title probability, displaces or reduces that complete truth which is a not specially expressed, but certainly incorporated element of what is meant by "C exceeds S." (Conversely "probably not" exhibits partial untruth.) Accordingly I interpret "C probably exceeds S" as meaning "I fully believe in the partial truth of the conception, C to exceed S." Whatever be then, in the mind, the actual variation of what is called belief, I conclude that, in thought prepared for linguistic expression, belief does not vary. Or, playing upon a current locution, I would have it that "softened assertion" is really the hard assertion of softened truth (or untruth). That, accordingly, which makes an expression assertive, is the presence (in its meaning) of the speaker's full belief—a belief it may be in the truth, the untruth or the partial truth of a thought—such truth consisting in the thought's being-paralleled, matched or duplicated, it may be by a phenomenon of the external universe, it may be even by a phenomenon of the speaker's mind itself—such phenomenon being regarded as external to the thought of the moment.*

Expression of belief.

The question by what element of the sentence the belief, or say the assertion, is expressed, is of small immediate importance. The opinion that this element is the personal ending of the indicative mode, is obviously inaccurate; for the same sign of person is often used in other modes, without assertive effect. On the other hand the "modal vowel," when it occurs, is doubtless distinctive. In its absence, it may be said that whatever in actual practice enables the assertive form to be recognized as such (e. g., the indicative flectional ending's difference from that of other modes) is the element which expresses assertion. So far as my observation reaches, the verb-forms which possess such assertive element are ranked as "indicative." Assertion, then, or belief (in truth or untruth), is part of the meaning of the indicative mode**—indeed, its exclusive privilege; for it is

*For instance, in "I doubt, fear, desire", etc., in which assertions the mere thought of my doubting is felt to be matched by actual doubt itself.

**That the indicative form is often used without indicative meaning, or as a pseudo-indicative (as in "I deny that Brown is honest", in which sentence the "is" cannot assert, as it does in the isolated "Brown is honest"), is merely one of many inconsistencies of speech.

possible, I think, to exhibit, as apparent only, all exceptions* and especially the exception offered by the imperative.

C. THE IMPERATIVE JUDGMENT *(expressed by a command).*

The fallacy of the imperative mode.

By ranking imperative expressions as modally different from the assertive forms of the indicative, grammarians create an embarrassment, of which I wish to rid myself, so far as may be, by discrediting the authority of Grammar. As an indication that this authority ought not to be trusted, I note that forms like "to fell" are, in the grammars of some languages, ranked as the causative mode of "to fall." As "to fall" and "to fell" have each its own indicative, subjunctive, etc.; and as some grammarians further recognize "conditional" modes of both indicative and subjunctive value (as in some Spanish Grammars); it may be imagined how a rational mind will fare with modes of modes, continuable, if fortitude fail not, to the *n*th degree of absurdity.

Again, if "to fell" must rank as a mode of some other verb, I cannot confine myself to conceiving it as the causal mode of falling. So far as meaning goes—and even also mental dominance—it seems to me that felling (and raising) are much more modes of causing, than of falling (and rising)—modes which, at a pinch, might bear the names of cadent and ascendant modes of causing. So too with "Move!"; I cannot perceive it solely as the imperative or commanding mode of motion; I must also see it as the mobile mode of command.

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*Thus the subjunctive (or other mode) in the conclusion of a condition, I should rank as a pseudo-subjunctive with really full assertive "intensity". For, even at its weakest, the conclusion is what I believe to be true in impossible cases (see p. 393); and such restriction of cases can hardly more invalidate assertion (or belief in truth) than restriction to no cases at all, as in "Lemons never exceed oranges". Yet, so far as I have observed, no claim is made that in this sentence "exceed" is stripped of any assertive intensity, although the scope of assertion is obviously reduced to zero. Again, as the merest piece of introspection, I note that, answering your "If you were three men, you wouldn't eat more", my "Yes, I should" appears to me to be as distinctly an assertion as any "shall" or "did" that I could utter.

Moreover, if one accession of meaning puts a verb into a different mode, fair play would seem to call for change of modal rank with other accessions. I see no reason for laying greater stress upon an added idea of command, than on the more effective, and so far more important, idea of aid. If an expression meaning "I command you to climb" have modal recognition, much more an expression meaning "I assist you to climb" would seem in ordinary justice to require modal recognition also. With the courage of this conviction, given "I help you over the fence" (meaning "I assist you to climb," etc.), I might announce this "help" as the cooperative mode of climbing, except that I mistrust me it should rather rank as the transcendental mode of cooperation.

Once started in the rôle of "modiste," I should hardly know when to stop. What is allowed with a first accession of meaning might also be allowed with a second—a third—a thirtieth. But as the vistas open—as there rise to view the modal possibilities offered for instance by "I desire to help to persuade you to attempt to cause to fall"—I renounce the effort to establish as modal what are obviously mere agglomerations of meaning—occur with the utmost frequency—in the greatest variety—with every sort of word. If, coexisting with the word "to fall," I ever find another word of similar form invested with the complex meaning of my illustration, I shall say that this word and "to fall" are merely different words. So also, given "Come!" and "I come," the meaning-difference between the "come" of one case and the "come" of the other might, in the interest of clearness and convenience, justify their recognition as two different words, alike in form alone. Indeed it would be well perhaps to do the like with every so-called mode which adds to the dictionary meaning of a verb any other meaning than the assertive element expressible by "I believe."

Or rather, to be even more consistent, I would with others rank the assertive form—that is the so-called indicative mode—as alone a verb. The so-called imperative, which I shall try to exhibit as the maker of a merely complex assertion—that is, as a so-called indicative with complex meaning—I would also rank as a verb, but as another verb.

The unassertive forms of conjugation might be ranked as members of an extra-verbal word-class—as what might well enough be known as hybrid parts of speech—more or less verbal in their power of gov-

erning other words—more or less something else in their government by other words.*

Regarding the imperative, not as a mode, but as an individual verb, I observe that its conjugation is defective, especially in comparison with what it might have been. Starting with a form for "I desire you to come" (say "Come!"), it was obviously possible for language to develop form-varieties meaning subjunctively "(that) I desire you to come," infinitively "me to desire you to come," and so on through the total range of verbal nouns, adjectives and adverbs. Variation for time, say tense, may occur not only with desire, but also with that which is desired; and the two variations may agree or disagree. The like is true of variation for person and number. In short all conjugational possibilities are open to the imperative, and each is often doubly available. Among the permutations and combinations mus producible I shall not take the risk of losing my way. Enough that speech has been contented with an insignificant part of their disheartening number.**

Its essential content.

This is plainly subject to variation. Some indeed have divided imperative expressions into many species—precatory, hortatory, mandatory, etc. These however may be overlooked in an investigation which more especially aims to discover the method of idea combination, than to increase the precision of ideas combined. I center attention on the general admission that imperative sentences stand for something more than the expressions hitherto examined.

To make that "something more" completely obvious, let an imperative expression be set in the light which may be shed by a contextual neighbor. Accordingly, "Eat that apple! *For I am not hungry.*"

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*Thus "I prefer your *wearing* black—you *to wear* black—that you *wear* black" exhibits the verbal substantive in turn as verbal noun, infinitive and subjunctive used as noun. In "I prefer persons *wearing* black—who *wear* black" the verbal adjective appears in turn as participle and as (in some languages) subjunctive used as adjective. "She sang ear-splittingly" exemplifies a verbal adverb, which at the same time takes an object and is operative as an adjunct to a verb. In Greek this usage may be found outside of compounds.

**I note, as somewhat interesting, that "May he go!" (not "May he go?") lies without the strictly imperative limit, as it fails to implicate the person addressed. On the other hand "Let him go!" is strictly enough imperative, but imperative of "Let"—and not of "go."

That my lack of appetite is used, in this expression, to explain or account for "Eat that apple!", may be assumed as granted by every one. So much indeed is clearly indicated by the "For." Plainly also the accounting is for something other than your eating of the apple. For to put my lack of appetite as explanation of your eating is hardly rational. If however "Eat that apple!" be taken to mean "I desire you to eat that apple," or "That you eat that apple is my desire," the situation is alleviated. My lack of appetite at least relieves my wish (that you exhaust the visible food supply) of any opposition which might offer, in case I were hungry myself. That is, what is explained (at least negatively) by "I am not hungry" is *my desire* that you eat the apple.*

The imperative expression being thus interpreted, the structure of thought expressed is easily perceived. The desire (that you eat the apple) is conceived as true; for otherwise the interpretation would be "I not desire, (or don't desire), etc." This truth, moreover, is believed; for otherwise the interpretation would be "me to desire, etc." Now neither of these last imagined interpretations would, as I suppose, be satisfactory to any one. I feel accordingly that what is meant in full by "Eat that apple!" is essentially expressed by "I believe in the truth of my desire (that you eat that apple, or) for your eating that apple)."†

*Whether ideas express by "I", "desire" and "you" be regarded as part of what is expressed by "eat", or as inferred by the hearer, does not seem to me important enough to warrant argument.

†I also perceive that when I use an imperative, for instance "Come!", I have in mind not merely a desire for your coming, but rather a desire that you put forth the energy required to bring about your coming. But so far as that I do not think it necessary to extend investigation.

Or again, as Sigwart will have it (Trans. Dendy—'95, Vol. I, p. 17), the imperative aim is not to express a wish, but to bring about the realization of a wish—an opinion quite incontrovertible, so long as "aim" is understood to be *ultimate* purpose. For when I say to you "Come!", no doubt the mere informing you of my desire is of too small importance to account for the evolution of a special form for imperative expression. No doubt moreover I have some expectation, or at least some hope, that you will be caused to come. But such causation is not, so far as I can see, a part of what I actually express. It (the causation) may be effected by influences of my own, coercive, intim-

Its distinctive.

Comparing "You eat that apple," interpreted as

(1) "I believe the truth of your eating that apple," and

"Eat that apple!", interpreted as

(2) "I believe the truth of my desire for your eating that apple,"

I note that, in the imperative judgment (2), an idea of my desire is thrust in between the belief in truth and the apple-eating of (1)—or say intercalated. The imperative sentence then is merely the assertion of a thought increased a trifle in complexity. In other words, to use a compact grammatical phrase, the imperative is a pregnant assertion.

Regarding rather thought expressed than its expression, I would have it that the imperative judgment is distinguished from an ordinary judgment by the presence of an idea of personal desire injected between belief in truth and the conception which, in ordinary judgment, is itself believed to be true.

D. THE INTERROGATIVE JUDGMENT *(expressed by a question).*

Limitation of field considered.

The scope of interrogative operations is far too great to permit their exhaustive investigation. Like the statement, the question may be embarrassed by negative elements. It may bewilder

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idating, persuasive. But all such I regard as strictly extra-linguistic. So far as I can see, the *immediate* aim of imperative speech is confined to letting you know what I desire, and that I desire it.

In making belief the foundation of the imperative thought, truth (or untruth) the basement of the mental edifice, desire the first and your coming the second story, I do not mean that, in the mind of speaker or hearer, the lower courses of thought-masonry are historically older. I imagine that the early thought-constructor was contented with the upper stories—that the lower ones are of more recent date, put in at great expense of effort, to meet a modern demand for thought-completeness and stability. Nor do I conceive them as mentally dominant. They are indeed more or less underground, below the level of completest consciousness. The superstructure is most in view, most in esteem. It realizes the preeminent purpose; all else is distinctly subordinate. On the other hand, not only in the architecture of stones, but also in that of ideas, the foundations cannot be neglected, if the building is to stand securely.

itself with alternatives. It may be overwhelmed by adjunctive clauses, adjective or adverbial, restrictive or informational. That too which prompts a question, and that which is merely surprising, are mentally so near of kin, that often it is far from easy to differentiate the question from the exclamation. That again which I do not know but wish to know, and what I neither know nor care to know, are enough alike to permit the symbol of one to replace the symbol of the other—to allow the two to act as interchangeable indefinites. Moreover the interrogative has all the degrees of vagueness that belong to the ordinary indefinite; and this vagueness may be that of kind, of number, of particular individual. [To illustrate, compare the questions "*What* killed Lincoln?"—"*How many?*"—"*What* actor?", "*Which* Booth?" and, in obsolete phraseology, "*Whether* of the two Booths?"] The question moreover may be doubled, as in "*Who* killed Lincoln *when?*" Question and simple command may coalesce, as in the French interrogative-imperative "Venez?" The question, as used by examiners and cross-examiners, becomes inquisitorial, aiming to test the knowledge or veracity of their victims, while the ordinary question is rather inquisitive or zetetic. The question may seek to mislead by false dilemma, to confuse by distorted perspective; or on the other hand it may take on the hermeneutic quality, being aimed to aid the hearer's cerebration. As indicated on p. 354, the question may appear as a questioned question—and also as a questioned factor of a question. Indeed it is obvious that, however difficult it be for the mind to form a given judgment of any sort, by reason of its extent and intricacy, and however awkward be the linguistic means of expressing that judgment, nevertheless any element thereof may be precisely that at which a question is aimed. In short there does not promise to be any difficulty of thought or speech, in which some form of question may not be involved. The question however offers ample difficulty of its own. To this accordingly I shall, so far as may be, confine attention, examining interrogation only as it appears in the simpler and more easily expressible forms of thought.

Indications offered by tradition.

These are few and disappointing. That "interrogative sentences are such as ask a question," and that "interrogative words

are used in asking questions," the naked eye can perceive.* To rank such words among the pronouns confuses the idea of the pronoun, as well as that of the interrogative word. The distinctive characteristic of a genuine pronoun (and I do not here consider any pseudo-pronoun—such, for instance, as the mere indefinite) I hold to be the restriction of its symbolizing power to the reinstatement (or anticipation) of a part or parts or all of a thought, which has been (or will be) expressed by another more effective word or combination. In "Yesterday I dined on mutton. *It* was very good," the pronominal "It" revives in mind the waning idea suggested first by "mutton." In "Yesterday I dined on mutton. *What* will the cook provide to-day?," the interrogative "What," with an eatable named by "mutton" directly at hand, neglects it absolutely. In "Though *he* is ill, Mr. Brown is at work," the "he" prefigures in the vague an idea which I inferentially promise to express more distinctly, fulfilling this promise by the words "Mr. Brown." In "*What* will the cook provide to-day?," I offer no such promise, for the excellent reason that I see no hope of fulfilling it.**

The distinctive feature of interrogation is sometimes said to be the "rising inflection." But this does not belong to questions only. If you ask me "Shall you go to the play?," I answer with rising inflection "I think I shall go;" indeed I may use throughout precisely the variations of pitch which the cockney uses in "To which house shall I go?" Again the question is not always put with rising inflection. In American English, although the voice is raised at the end of "Are you there?", it falls at the end of "Where are you?"

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*That language students universally endorse such definitions, mainly offered by Grammar, I do not for a moment suppose. That real investigators are discontented, many of them ready to revolt, some independently holding to rational views, and giving them welcome expression, would seem to be a foregone conclusion. To the opinions of such I hope only to bring the merest confirmation. Their opinions are not what I mean by Grammar. I mean the body of observations, definitions, classifications and explanations, adopted as creed or endured as fashion by teachers and writers, with rare exceptions.

**The "What" in a sense anticipates the answer; so too in "Lend me five dollars!" the "Lend" anticipates your act of lending; but such anticipation is far too different from that of the pronouns, to furnish ground for entrance into their category.

Equally futile is the effort to establish, as distinctive feature of interrogation, an inverted order of words. On the one hand questions are asked without its aid, as for instance "Who is there?" On the other hand, inversion does not always make a sentence interrogative. In the closing lines of Locksley Hall the inverted expression "Comes a vapor from the margin" does not intend a question.

While then it must be admitted that rising inflection and inversion are used as helps to indicate the interrogative meaning, it seems to be proper, in view of their frequent omission, to rank them as only helps.

Discarding these and other purely formal characteristics, I propose to look for one substantial and essential, expecting to find it, as a matter of course, in the thought itself, which interrogative expression embodies. I turn accordingly to interrogative thought, and, first of all, to

Indications offered by concurrent mind-phenomena.

Under this title I wish to repeat the experiment performed upon the Imperative—to examine the mental status pictured by the question, in the light which may be shed by a contextual neighbor.

In Hugo's "Toilers of the Sea" I find that Captain Lethierry, overflowing with gratitude to one Gilliatt, a sailor, picturesquely asks "Where is he? that I may eat him." Examining the mental status of the questioner, I find an intention to eat Gilliatt, concurrent or coincident with whatever other mental state may be expressed by the question. The question itself is apparently aimed to aid that intention. Conversely the intention explains or accounts for the question. Taking inventory of the latter, I find, at first sight, only that "Where" conveys the idea of unspecified place; that "he," otherwise Gilliatt, suggests a person; that "is" encourages some faith in that person's being in that unspecified place. In short, the utmost that I can rightly or wrongly develop from the dictionary values of words employed, is that Gilliatt is somewhere. This is hardly definite enough to invite explanation; and even if it did, the explanation offered by "that I may eat him" would hardly be sufficient or appropriate. Accordingly I feel obliged to find in "Where is he?" more meaning than at first appeared. The like is true of the following illustrations: "Where is the water-pitcher?—for I am

thirsty." "Since I can't eat cake, haven't you any bread?" "Where is your pencil, if you can't find a pen?" With all of these I feel obliged to find, in the meaning of the question, something more than at first appears. Of what this something is, I hope to find an indication in the next succeeding sections.

Its occasion.

This I take to be the conscious insufficiency of a previous conception. In a later section I shall try to show that what creates the insufficiency of a conception is at times the absence or offensive indefiniteness of a conception-element—e. g. (1) "Booth to have killed . . . ." or "Booth to have killed some one," as compared with "Booth to have killed Lincoln"—and at other times the lack of that belief which, if experienced, would change the conception into a judgment—e. g. (2) "Booth to have killed Lincoln" as compared with "Booth killed Lincoln." Strictly speaking, the mental total assembled (before the asking of a question) in case (1) is hardly an actual conception at all, but rather a would-be conception, or a make-shift for a conception; and in case (2) the mental total is insufficient, only when appraised as if it were a judgment—which indeed the thinker may have wished it to be, but which it is not. The fact of immediate importance is however that in either case the mental total, as compared with what the speaker is assumed to wish it were, is distinctly insufficient. Accordingly, as I am planning to present that only, for the moment, which is common to the two varieties of insufficient thought—common to their natures, and common to their augmentations into interrogative judgments—I venture to use for both that single name (i. e. insufficient conception) which most will help me to maintain them both in mind together—help me also clearly to distinguish them, as will appear, from other forms of thought already examined.

Meantime I do not wish to be understood as implying that the less one knows about a matter, the more he will strive to know. For while it is generally true that what I know I shall not ask, it seems to be universally true that I shall ask nothing in regard to that of which I know nothing. Thus, in the matter of Catiline's banishment, if I have never heard of Catiline, of Rome, or of banishment, I am certain not to ask a question as to either one, or any combination of them; and even if I had heard of Catiline, but nothing further, I should be more apt to

request you to tell me about Catiline, than to ask you a specific question. But if I knew that Catiline had suffered banishment, I might inquire what city banished him. In short, the question may occur when knowledge is incomplete, but not when it is null—and rather when that which is missing is a single element, than when it is two or more.*

Its motive.

This appears to be the desire for knowledge—the desire to make sufficient a conception consciously insufficient. Such insufficiency alone can hardly lead to a question. It must be attended by that dissatisfaction, of which a desire to mend the insufficiency may be regarded as the active phase. To illustrate, "Brown has gone somewhere." Admitting that I do not know where he has gone, so long as I am personally satisfied with my absolutely rather insufficient statement, I shall not ask a question. I don't know, don't care and shall not try to learn. When, however, I not only do not know, but also care to know, then and then only shall I try to know.

Means of making a conception sufficient.

(a) By one's own effort:

To illustrate, not knowing the number of your house, and wishing to know it, I may go to your house and find out for myself. Such expedients I discard, as plainly foreign to the matter in hand.

(b) By the effort of another:

(1) extra-linguistic.

(2) linguistic.

The former I neglect entirely. The latter I consider, but only when direct and special. Your diary, for instance, and your published theses, constitute linguistic efforts eminently helpful, on occasion, to the seeker after knowledge. But you did not make them specially to meet my need, nor did you aim them directly at me. Valuable as they are, they do not promise to illuminate the problem of interrogation any more completely or effectively than linguistic efforts made by you especially in my behalf, and in my mental presence.

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*The case of momentary failure to remember—that is, momentary ignorance—may be dismissed as promising nothing of special value to the present investigation.

The effort of another implies solicitation:

(1) extra-linguistic.

(2) linguistic.

In other words, the chance that you will help me mend a conception without request (or some equivalent) from me to do so, is too small to be considered. Extra-linguistic means of prompting you to effort, I neglect in favor of the linguistic; and of these again I shall examine those alone which are direct and special, excluding every indirect appeal "to whomsoever it may concern" and every standing, hourly operative "Please help the blind!"

Linguistic solicitation may be inferential or explicit.

(a) Inferential:

That human ingenuity, under stimulus of sore need, should hit upon many ways of obtaining knowledge, without over-stepping the bounds above established, would seem to be a foregone conclusion. Of possible expedients I will exhibit a few, making use of an illustration which easily bends itself to different forms. Supposing then that I do not know, but wish to know from you, the cause of Brown's ill-humor, I might say merely that

(1) "Brown is ill-humored," relying on this announcement to stimulate you to an explanation of his temper. Better yet I might say that

(2) "I don't know the cause of Brown's ill-humor," or

(3) "I doubt the cause of Brown's ill-humor." I might also succeed with

(4) "Something is the cause of Brown's ill-humor," or

(5) "—— is the cause of Brown's ill-humor," or merely

(6) "The cause of Brown's ill-humor." I might, moreover, start you with a proposition of alternatives, as

(7) "Gout to be or not to be the cause of Brown's ill-humor." I might also feebly announce that

(8) "I suppose that gout is the cause of Brown's ill-humor," or flatly declare that

(9) "Gout is the cause of Brown's ill-humor." If neither of these aroused you, because you share the opinion expressed, I might rely on your antagonism to bring you out of your shell, on substituting

(10) "Gout is not the cause of Brown's ill-humor." If none of these things moved you, I might put you on your defense by

(11) "You think gout is the cause of Brown's ill-humor," or

(12) "You think gout is not the cause of Brown's ill-humor." Or I might tickle you into an answer by the Irishman's combination of (9) and (2)

(13) "Gout is the cause of Brown's ill-humor, I dunno." Or, becoming more emotional, I might try you with

(14) "I'm sorry I don't know the cause of Brown's ill-humor,"

(15) "I wish I knew the cause of Brown's ill-humor,"

(16) "(Oh) that I knew the cause of Brown's ill-humor," or

(17) "The cause! The cause of Brown's ill-humor!"

By these and doubtless other means you might be led to infer my general desire for information, and even my particular desire that you inform me, especially if you are of an obliging disposition, and keenly on the watch for a chance to show it. The uncertainty of such expedients, however, justifies the expectation that there will be found in language methods more

(b) Explicit.

Outside of the question itself, for instance

(1) "What is the cause of Brown's ill-humor?," I recall but two expressions which make an explicit appeal to another's linguistic aid in making a conception sufficient. These are

(2) "I wish you to tell me the cause of Brown's ill-humor," and its imperative abbreviation,

(3) "Tell me the cause of Brown's ill-humor," both of which will be examined somewhat closely in juxtaposition with strictly interrogative forms.

Answering now the possible query 'What interrogation is,' I feel it safe to say, in a general way, that it is one of several direct and explicit linguistic means of inducing another mind to give particular information. An exacter comprehension I hope to reach in chapters III and IV.

Its control.

By this I mean the influences which mould the interrogative judgment to a particular form; and these I find in the elected means of making a conception sufficient.

To illustrate: If I do not know but wish to know the num-

ber of your house, and plan to mend my ignorance by personal investigation, I meantime hardly feel the need of forming any judgment whatsoever, beyond the judgment which I may have based upon conception altogether insufficient—an imperfect judgment which may be expressed by "The number of your house is ——."

But if I plan to utilize your aid to mend my ignorance, I must be conscious in the first place of my plan. Moreover, in order with success to operate my plan, I am forced to reveal it to you. Again, to accomplish this revelation, I must meet the usual conditions of communication; and these require that first of all I make you of my plan a mental picture of the sort that language is constructed to express. That is, I need to form for you a judgment descriptive of my mental status.

Its essential content.

Such a judgment must contain the element of my belief or knowledge. For if what I set before you seemed to you to be uncertain even to myself, you very well might turn your back on me at once, as one who very strictly "does not *know* what he is talking about."

In the present case my belief must be in the truth of my description. For descriptions which are not true—that is, descriptions to which my mental status or experience does not correspond—are plainly quite irrelevant.

My mental state is, in the rough, and roughly speaking, a desire. That is, I experience a quasi-emotion with respect to an effort (conceived as to be made by you) to make sufficient a prior conception which was insufficient.

Obviously this desire and that effort must appear in the mental picture to be set before you.

As that effort is to take linguistic form and be a revelation to myself, it may be known as a "telling me by you," or as "your telling me," or "that you tell me." Accordingly my judgment, thus far constructed, is expressible by "I believe to be true my desire that you tell me ——."

Plainly this is not enough. I must put myself in your place —realize your ignorance of my mental status, your inability to know that status otherwise than by my aid—particularly I must somehow help you to discover what it is that I desire you to tell me.

Proposing to discuss the means of such a helping in the following chapter, for the moment I describe the telling and what is to be told, as another person's making a conception sufficient by linguistic means. Accordingly, as the essential content of an interrogative judgment, I rather vaguely nominate "belief in truth of desire that by linguistic means another make a conception sufficient."

Its distinctive.

The forms of thought thus far compared—conception, ordinary judgment and imperative—have constituted a crescendo, each except the first containing an element foreign to the form preceding. Expecting now, as indicated in my second sentence (on p. 354) to find another term for this crescendo, I compare the essential content of (1) interrogative with that of (2) imperative. Accordingly,

(1) "belief in truth of desiring that by linguistic means another make a conception sufficient."

(2) "belief in truth of desiring (what is conceived, or say) a conception."

Subtracting (2) from (1), I obtain as a remainder, "that by linguistic means another make sufficient," or say "another's making sufficient by linguistic means." This remaining element of thought being, as I must believe, in every case an element of the interrogative judgment, and never of the imperative or any other uninterrogative form of thought, I nominate it as distinctive of the interrogative judgment.

The interrogative accordingly is merely an imperative increased a trifle in complexity—in other words, a pregnant imperative.

Its genera.

These are naturally based upon the different kinds of insufficiency which may exist in a prior conception.

These kinds of insufficiency—impedimenta necessary to a line of mental march which thus far has been single—it has been convenient hitherto to carry in a single bundle. Henceforth lines of reasoning on which I need them are divergent. Let then the contents of the bundle be divided.

These contents, or these kinds of insufficiency, are two. A conception may be insufficient because it lacks a conception-

element; for instance "Booth to have killed ——." In such a case it is obviously insufficient, not only as a conception, but also as a judgment. Again, a conception may be insufficient because, though quite sufficing as conception, it fails to be the judgment which the thinker wishes that it might be; for instance "Booth to have killed Lincoln." In either case accordingly the thought-form ranked thus far as an insufficient conception may, from a different point of view, rank also as an insufficient judgment.

Now as a judgment is a conception plus belief, and as—in theory at least—belief may be added to any conception, possible kinds of judgment-insufficiency include all possible kinds of insufficiency in a conception. Accordingly we may drop the consideration of conception-insufficiency and take up that of judgment-insufficiency, without any danger of overlooking any element of judgment or conception.

Of judgment-insufficiency there plainly may be reckoned as many kinds as there are kinds of judgment-elements; for the absence of any element is possible and constitutes, if actual, what may be felt as insufficiency; and insufficiency in each case may be recognized, if so elected, as a special type.

Of judgment-elements I recognized, in the simplest case, the following kinds:

(1) A primary mental unit or thought—or say a conception—consisting of two ideas and their relation;

(2) The truth (or untruth) of this thought;

(3) Belief in this truth (or untruth).

Whether (2) is ever absent from a would-be judgment, becoming what a question aims to supply, may be examined later. (See p. 446.) That (3) may fail to attend a thought, has been sufficiently indicated in the treatment of conception (pp. 387–388). Assuming for the moment that belief may some times be what a question aims to establish; assuming the like of each primary idea, or term, of (1); assuming the like of every adjunct possible to any term of (1); I see that the interrogative judgment may be interrogative as to—

genus (1)—a term or adjunct,

genus (2)—belief.

The former genus is intended by the current expression, "the interrogative sentence with (specially recognized) interrogative word;" e. g. "Who saw you?," "Whom saw you?," "What man saw him?," "What man saw he?," "Where saw you me?" etc.

The latter genus is intended by the current expression "the interrogative sentence without (specially recognized) interrogative word;" e. g., "Saw you my brother?," "Are you tired?"

Any danger that these genera fail of mutual exclusion—that some question will at the same time ask for a term or adjunct, and for belief—is unimportant. There will probably not be any serious asking of a question such as "Saw you my brother where?" or "Is who tired?" Mental modesty may be expected to inhibit the display of mental nakedness so extensive. Such nudity—or, dropping figure of speech, such ignorance—will rather be revealed on the installment plan, by successive single questions.

CHAPTER III.

THE JUDGMENT INTERROGATIVE AS TO A TERM OR ADJUNCT.

To illustrate this, recalling the assassination of Lincoln, and wishing to form a judgment containing the actor, the action and the victim, or say the actee, I can get no further than what might be expressed by "—— killed Lincoln." But, having faith in your superior power or knowledge, I am going to ask you to put into my mind an idea which shall fill what may be called a thus far vacant mental space.

My case has some analogy with that of Nebuchadnezzar, requiring "the magicians and the astrologers and the sorcerers and the Chaldeans" to tell him a dream unknown to them and forgotten by himself—or that of Huckleberry Finn, who expects the dictionary to give him the spelling of a word which he can not, however, indicate, because he does not know its spelling.

To me accordingly the linguistic feat to be accomplished by a question is simply astounding. Before you can aid me by an answer to my question, I must cause you to think of an idea which is not in your mind; and this idea I can not arouse in your mind by the usual verbal stimulus, because the word for that idea and even the idea itself are absent from my own mind.

Though difficulties to be met are extraordinarily great, the means employed to meet them are absurdly small (Conf. "Who killed Lincoln?"). Their success—overriding, as it does, all adverse probability—seems to me a challenge to investigation, which the language-student can not honorably decline.

ITS ELEMENTS.

In trying to establish these a little more exactly than was done above (pp. 409–410) it is well to begin with what apparently determines the selection and arrangement of the others, namely, that which roughly may be called

The missing element.

The interrogative operation has its analogy with the making of a cannon—described, in a well-worn story, as accomplished by taking a hole and putting some iron around it. For the moment, I pursue this analogy only so far as to remark that the interrogative judgment also starts with, so to speak, a hole. The absence of an element from a previously attempted judgment strictly constitutes a mental zero, a vacuum, or say, a void. For instance, given the expression "—— killed Lincoln," it may be assumed that initially no idea whatever is in the mind, to correspond to what is indicated by the blank.* In using then the phrase "the missing element," or "absent element," I really wish to suggest the void left by the absence of that element.

The desideratum.

By this I mean the desired element. Having realized that in my attempted judgment there is a void, I next experience, if I am to develop an interrogative judgment, a desire for what will fill that void. I certainly do not desire the void itself. What I do desire is, so to speak, a void-filler. Thus, given "—— killed Lincoln," if I base thereon a question, what I shall wish to learn and what I shall ask you to tell me, will not be a blank, but that which suitably may take the place of the blank.

That which the blank expresses may be well enough described by calling it nothing. That, on the other hand, with which I hope in the end to fill the void, is to me quite positively something. The difference between the two is the difference between not being and not being known. The desideratum accordingly is to me an indefinite. Expecting to develop this doctrine, I note for the moment that any interrogative word may be expected to appear as merely a somewhat peculiar modification of a corresponding indefinite.

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*Though I be able to say that "Some one killed Lincoln", or even "An actor killed Lincoln", still, if I ask "Who killed Lincoln?", it is obvious that, so far as compared with any *desired* judgment—and with this I ultimately have to deal—a void exists when I can only say that "Some one killed Lincoln", quite as truly and distinctly as if I were only able to say that "—— killed Lincoln."

Description of desideratum.

The asking of a question presupposes that my effort to fill the void in a prior defective judgment will not assume the form of personal investigation, but will begin with an attempt to obtain from you a void-filler. The ultimate filling of the void will naturally be done by me; but what I use, to fill it, you must first supply me.

In the cases to be examined, what you are to furnish—that, in other words, for which I come to you—is a single idea. But, in coming to you for this, I bring along the ideas which I already have. For instance, if on "—— killed Lincoln" I base a question, it will take the form of "Who killed Lincoln?" That is, in begging material to complete "—— killed Lincoln," I bring with me "killed" and "Lincoln."

The superficial oddity of this may be emphasized by the following illustration: Proposing to breakfast on ham, eggs and coffee, but having no eggs, I enact a quest for them, going to your market-stall, basket on arm, to get them. But I do not put in the basket the ham and the coffee. For why should I bring you the already collected elements of my breakfast, when trying to get from you an element which as yet I do not have?

On closer examination my illustration proves to be misleading. As a seller of eggs, you will ordinarily learn that I want them, from a verbal exhibition of my wish, quite independent of eggs themselves, or coffee or ham. To make my objective illustration parallel to that exhibition of ideas only, to which we give the name of speech, I must make the former an exhibition of things only. Let then my effort to get the eggs be a "dumb show." Accordingly I present myself with my basket. Were I proposing to sell, I should be more likely to bring my wagon. From the smaller receptacle you may succeed in deducing the stronger probability, that I wish to obtain and not to deliver. If now, looking into the basket, you find the already purchased coffee, you may further infer that what I have in view is a breakfast. The sight of the ham will partly strengthen this inference, and partly further suggest the remaining element of the breakfast which I contemplate, namely, eggs. In short, from what I have you may infer what I wish to have.

In coming to you for material to fill the void in a thought, my case is quite analogous. To illustrate: I have the elements "killed" and "Lincoln," or say "—— killed Lincoln." The other required element I indicate for the present by a blank, for

the excellent reason that it is not in my mind. That is, in my attempted judgment there is a void.

Suppose now that I come to you with this void alone, without surrounding elements, and ask you to fill it. In the beginning, says the Scripture, "The earth was without form and void." Likewise what I bring you is not only void, but also without form. I offer you vacant mental space without its contours.

To fill this space, however, as I would have it filled, not every form of thought-material can be used; nor is there any universal stop-gap for mental emptiness—no answer suitable to every question. To enable you to choose aright, I must, to speak with the utmost objectivity, establish for you the contours of the void. This I do by imitating the fantastic building of the cannon. Around a hole I put some iron. About the mental void I gather elements which serve as boundaries. I establish, so to speak, the edges of the void—in other words, its mental environment. This environment consists of those thought-members which already are in mind. The void and this environment being then coterminal, the existing thought-members may be said to furnish the boundaries of the void.

Now the void is not, of course, what I wish to obtain from you. But, as the void must be exactly filled, its boundaries are those of the element which is to fill it—the desired element—the element which the question aims to obtain; and these boundaries—or ideas which I already have—the question does express. Accordingly I may say that in asking you a question—that is, in asking you for a void-filler—I give you the void-filler's boundaries.

Now boundaries are in the strictest sense a definition. We are then prepared to learn that, when an interrogative judgment is formed, ideas already found will be used as definition of an idea yet to be found. Thus, given the uncompleted thought expressed by "—— killed Lincoln," it is quite impossible for you to think of the required thought-element, except so far as you be guided by a definition (description or determination). But the only definition I can give you is that afforded by "killed Lincoln." That is, the mental desideratum must be distinguished from other thinkables by its fitting what may be summed up as "Lincoln-killing."*

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*With a little anticipation I can further indicate that ideas already in the questioner's mind are offered and accepted, as defining the idea

Postponing the effort to determine how the definition, or description, operates to realize its purpose, I take up next the

Assertion of description.

The indications that description is asserted, so far as I can find them, are derived from introspection. To illustrate, suppose that one of several persons standing behind me strikes me on the back. Turning toward them, I ask "Who *dared* do that?" While I shall argue that every question affirms my desire to be informed, I am sure that in this question I also mean no less to announce my conviction that he who struck me was very daring. Indeed, my emphasis, so far as it may be trusted,

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which the question aims to obtain. To illustrate, suppose that, as we enter the clubroom, you notice on the rack a very striking hat, and ask "Who owns that hat?" I answer "He has remarkable taste!"

By this "He" it seems to me I plainly mean the person distinguished from others by owning that hat; and though, after thinking of such person, I have wandered off to matters altogether foreign to your purpose, still, in using your "owns that hat," as definition of the person to be thought of, it seems to me I have done precisely what you wished.

Now had the remainder of my answer been exactly what you wanted; had I, for instance, said "He is the mayor", or "He who owns that hat is the mayor", it seems to me my use of your "owns that hat" would still have been precisely the same—and, surely, the very use that you intended.

With a little change this illustration will throw further light on the "Extent of Vicarious Usage", examined on pp. 32, etc., of the "Revision of the Pronouns." Suppose accordingly that, on the occasion just imagined, you ask, "Whose hat is that?" and that I answer as before "He has remarkable taste."

Roughly speaking, "Whose" and "He", as I take it, contemplate one person. Moreover "He" can have no sufficiently definite meaning, except so far as it presents to mind a second time ideas first presented by other words. Accordingly the idea-presenting power of "He" is what may be known as vicarious, and in this case reinstative, as distinguished from anticipative. The reinstative act however is, in the present case, of a most peculiar type.

While the awkward expression "Whose hat is that?" no doubt intends me to distinguish a person from others by his owning the hat, the form in which the expression is put is that adopted to distinguish the hat as owned by a person, just as in the expressions "his hat", "John's hat", "the hat of John" or "the hat owned by John." That is, the impression

seems to indicate that I even more intend to assert my opinion of my assailant, than to find out who he is.

This dominant intention seems to me to be a survival from an earlier state of mind. Reviewing the mental history which culminates in a more ordinary question, e. g., "Who killed Lincoln?", I find a moment at which the thought which the question aims to complete, was an attempted, though a baffled judgment. I should not ask you to tell me who killed Lincoln, except as I feel sure of an occurrence in which Lincoln met his death. Although this occurrence is ultimately used to describe its missing protagonist, I come to the description in the assertive state of mind.

This state of mind continues while I make my description. I do believe in a phenomenon, perceived as an ideal trinity composed of actor, act of murder, and victim—and not a whit the

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strictly offered by "Whose hat" is the one conveyed by "the hat owned by whom", or say "*the hat of a whom.*"

When now I answer "He has peculiar taste," the person meant by "He" is the person meant by "Whose", appearing a second time upon the mental stage. But the actor, so to speak, in the mental drama has, on this second appearance, lost his former fellows. "Whose", like the "Who" of other examples, was attended by interrogative elements; but by these the "He" is quite deserted. Again the "Whose" not only meant "a person', but also meant "possessed by", and this latter meaning also has forsaken the person meant by "He."

But these defections are offset by considerable reinforcements. As introduced by "He" the person reappears upon the mental stage in quite a goodly company, of which it is moreover chief—a principal term, with a retinue of adjuncts. For "He", as I take it, means "the person owning the hat", or say "*the He of a hat.*"

If then "He" be accepted as the reinstater of "Whose", the following changes have occurred:

(1) The interrogative power of "Whose" is lost.

(2) The relation named by "owned by" (that is, the relation of property to owner) has been replaced by (the relation of owner to property, that is) the relation named by "owning."

(3) The idea named by "hat" is introduced by a second reinstative effort.

That is, in the process of reinstatement, while a fundamental identity remains intact, a large contingent of ideas has been lost (that is, the numerous ideas which constitute interrogation)—a relation reversed—a new idea added.

less completely, from having no particular actor in mind. In short, the incompleteness of a thought is not a bar to my believing it to be true. The superficial implausibility of this doctrine is relieved by the sentence "Lincoln was killed." In this I have, as before, no doer of the killing—strictly, then, no actor. Yet I declare my belief in the truth of my substantially no less defective thought, without a trace of embarrassment.*

I have moreover a special motive for holding fast to my belief and revealing this belief to you. For it is, ordinarily, as implicated in an *actual* occurrence, that I wish you to conceive that actor of whom I am myself unable to think. What I wish to learn is not who might have killed Lincoln, but who as a matter of fact *did* kill Lincoln. But actual fact, as I have argued, cannot be expressed by words. The nearest linguistic approximation is thought believed to be true. Wishing then to put before your mind the killing of Lincoln as a fact, the best that I can do is to express to you my mental correlative of this fact, or say my thought, and add to this thought my belief that it is true—in other words, that it is matched by fact. I conclude accordingly that my defining is assertive—that "killed," beyond the naming of a particular act, expresses what I might express by the words "I believe to be true," which would apply, of course, to the total thought expressed by "—— to have killed Lincoln."

I do not, however, claim that the defining element of a question is asserted always. Indeed, there are cases in which I see an excellent motive for non-assertion. To illustrate, I will utilize a very neat distinction between assertion and non-assertion, which is revealed by French in the expression of the following thoughts:

(1) I seek a servant (e. g., one John Brown), whom I believe to be faithful.

(2) I seek a servant (as yet an unknown quantity) whom I merely conceive as faithful.

Of these the first is regularly expressed by a sentence exactly

*The fact that the current of my thought is, when I make my statement in the passive voice, reversed, involving the substitution of the reverse relation, seems to me in the present case to be without importance, although this passive statement differs from my "——killed Lincoln" in this respect, that while in either case I know not who killed Lincoln, in one case I do not care (or even perhaps consider) but in the other I do.

equivalent to "I seek a servant—*who is faithful,*" which is a mere variation upon "I seek a servant. He is faithful." The second is, however, regularly expressed by a sentence exactly equivalent to "I seek a servant *who be faithful;*" that is, I seek a particular kind of servant. Now it is natural to expect that what is meant by each italicised expression will be made the basis of a question. Such a question, once reduced to the usual brevity, would appear in either one of the following forms:

"Who is faithful?" and

"Who be faithful?"

I cannot, however, see that my desire to be informed is any less completely felt, or any less surely vouched for (as I shall later argue) in the subjunctive question, than in the other. I therefore hold to merely this, that the descriptive element of the question *may be* unassertive—a possibility sometimes realized in several languages.

The special importance of this usage is the guidance which it offers to the search for that member of a question which asserts desire. If it be true (as I shall argue) that a question always does assert desire—and also true that the defining element of the question sometimes does not assert—then surely desire-assertion will at least sometimes be found outside of the descriptive verb. For instance, in the question, "Who killed Lincoln?," I shall surely *sometimes* find outside of "killed" the assertion of my desire (that you tell me who killed Lincoln).

Desire to be told desideratum.

When the desired element of thought has been identified, no doubt the major difficulty of the question is overcome. But the wish to be told this element should also be made evident. The words "killed Lincoln" may succeed in causing you to fix your attention on the idea (e. g., that expressed by "Booth") which I wish you to put into my mind. But, in fixing thus your attention, you merely parallel the act of him who obligingly carries out my request to "stick my fork into the biggest one of those potatoes yonder." What I wish to obtain is, in each case, selected from its fellows; but I do not in either case make it unignorably clear that what has been selected I also wish to obtain. Unless my hearer be sufficiently acute and obliging, the potato may remain in the dish, and the desired idea may remain in another mind. Its revelation to me could only be the result

of an inference, on which so important a linguistic act, as the question, can hardly be supposed to rely.* It may then rank as a foregone conclusion, that the speaker's desire to be informed will be accepted by the hearer, as part of what a question is intended to express. Accordingly, in the question "Who killed Lincoln?," I feel sure that words employed will not only express that definition of my desideratum, which resides in "killed Lincoln," but will also in some way express as much, at least, as what might be expressed by "my desire that you tell me that desideratum."

Assertion of desire.

Language is commonly defined as a means of conveying information. To the student of interrogation it is, however, obvious that language is also a means of soliciting information. Of these two operations, the latter seems to me to presuppose the former. For surely I shall not conceive the extremely complex act of asking you to give me information, until I have conceived the vastly simpler act of merely giving information; and my conception of information-giving can hardly be supposed to have become availably distinct, until developed by realization in actual practice. If then one of the two (the ordinary statement and the question) be derived from the other, the question is presumably derived from the statement. Moreover, that a deriva-

*That the question did at first rely on precisely such an inference, I regard as essentially beyond a doubt. The history of the compacter language-forms and those which express ideas of major difficulty, exhibits commonly an early stage in which even the dominant idea is left to inference. Thus, in "It rains. I shall however take a walk", the antagonistic relation between the walking and the raining could not at first be felt as part of what is meant by "however"—a word initially expressing only manner or condition indefinite to the utmost degree, being merely an essential synonym of "anyhow." But in time this antagonism, being constantly intended by the speaker, and constantly inferred by the hearer, came to be felt as part of what was actually expressed, and elected the word "however" as its symbol, forcing that word to mean "in spite thereof" or "nevertheless." So, too, in the case of the question, what at one time was nothing more than occasional inference, came to be regular, was next accepted as part of meaning expressed, and finally elected, as I hope to show, a particular sentence-member as its symbol.

tion of one from the other should occur, is somewhat to be expected. The development of speech being a successive adaptation of old means to new ends, it is a priori likely that the question be an adaptation of a preexisting means of expression. I shall not therefore be surprised, if the interrogation prove to be merely an adaptation of the statement. I feel, however, that such proving must come from further indications.

Of these, the practical indication has some value; I mean that the mental cargo carried by the verbal vehicle must be assertive, to justify the expense of transportation. Such is peculiarly the feeling of the hearer, whose share of the effort entailed by thought-communication is even greater than the speaker's. Given, for instance, the assertion "I believe it to be raining"—or, more briefly, "It rains"—you find some value in the personal quasi-knowledge which it offers you. But to the expression "It to be raining" (and nothing more) you very properly object that, if the speaker is without assurance that the figment of his brain is matched by something more substantial, he might as well—or even better—maintain a golden silence.

This proposition obviously holds of language, only in its service of the understanding. Undoubtedly it does not hold of poetic utterance, in which the extra-utilitarian value of a mere imagining—say, to go no further, its sublimity or beauty—is ground enough for its exhibition, altogether independently of any one's belief that it is true. Admitting then that, in a frequent, valid and important usage, speech is free of any obligation to assert, I merely claim the right to examine exclusively the other usage, believing that in it the operative method of the question will be most easily discovered, and also that whatever be discovered will be quite available with what is not examined. Accordingly, in every independent expression of the type to be examined, the interrogative as well as any other, I expect to find the speaker's knowledge or, to be more accurate, his supposition that he knows—that is, his belief. In other words the question itself will presumably be assertive.

The indications thus far noted in this section would, so far as valid, establish only this—that, in the thought expressed by a question, there is assertion somewhere. That assertion bears upon the particular element of desire, can be established only, so far as I can see, by the speaker's introspective study of the thought which, by a question, he proposes to express. The effort

of the moment being to determine whether desire be or be not asserted in the question, suppose we paraphrase the question by two different expressions, one assertive of desire and the other not, and ask ourselves which one the better shows our meaning. Accordingly, given the question "Who killed Lincoln?," I paraphrase by

(1) "I desire you to tell me who killed Lincoln," and

(2) "Me to desire you to tell me who killed Lincoln."

For myself, I am as sure as I can be, that I mean the former. I wish you to think of my desire not merely as imagined on my part, but as actually occurring in my mind. Appreciating the difference between merely entertaining a thought of desire, and actually experiencing desire, I wish you to understand that the latter is my present status. Being, however, confined by language to the expression of the former (Conf. pp. 360 and 380), I can virtually transform it for you into the latter, only by putting it as matched by the latter, and adding my belief in its being so matched. In short I think, in full, what I express by "I believe it to be true that I desire, etc,"—or, more briefly, "I desire, etc." When then I ask you "Who killed Lincoln?," I shall surely be dissatisfied, unless in some way you understand from my question, not only what it is that I desire, but also my mental state of desiring—a state not merely imagined on my part, but actually experienced, or, by linguistic transformation, believed by me to be true. I must therefore conclude that in a question I assert desire.

Indeed I cannot think that, in a formula doubtless adopted for the very purpose of ultimately gratifying a desire to know, the actuality of that desire could be put with less distinctness than the actuality of ordinary statement—that is, the revelation of what I know already—the announcement largely, so to speak, of desire already gratified. I might almost as well expect my dog to show his satisfaction with the recollected bone I gave him yesterday, more eagerly than his longing for the one he expects me to give him, as I go to the cupboard now.

Precedents for double assertion.

Though frequent in form,* two assertions in substance are not extremely common within the limits of a single sentence. One charge at a time is the rule for guns and for statements. Yet double assertion is distinctly recognizable in "I have a letter from my wife, who is in New York", in which expression the relative clause is obviously propounded by reason of its self-sufficient informational value, quite as certainly as the separate sentence "She is in New York." But this asserted relative clause is not employed for the purpose of telling you what wife I mean. That is, it is not restrictive, or definitive—not on a par with the "who killed Lincoln" in "I wish you to tell me who killed Lincoln (or the person distinguished by killing Lincoln)." To parallel the interrogative expression, as interpreted, I must find a case in which the relative clause, asserted because informational, is also of a restrictive or definitive character.

Such a case I think I find in the following illustration: "I want a book which you will find on the newel post." This sentence is quite inadequate, if I stop with "book"; for what I want is far from being *a* book; it is *the particular* book distinguished by its being on the newel post. To this book I confine your thought by a description which isolates it from all others. I am sure then that my relative clause is restrictive, descriptive or definitive. I feel also sure that it is asserted. I admit that on such occasions I commonly prefer, in my description, to draw upon what you already know—what I therefore do not need to assert. But in the present case I stipulate that you know nothing of the book's location. It is natural therefore that I give you the missing knowledge and by the usual means—that is, by an assertion. I might no doubt rely on merely associating in your mind the idea of location with that of the book. I might accomplish this by the expression "Bring me the book on the newel post." But so far as I know myself, I choose the usual course. As you don't know where to find the book, I declare outright that you will find it on the newel post, expecting you to use this newly given knowledge, to guide you to a particular book. That is, my asserted informational clause is at the same time distinctly restrictive. There being also an obvious assertion in "I want," my illustration offers two assertions, one of which restricts an element of the other. The illustration therefore seems to me to countenance the precisely parallel assumption that, in "Who killed Lincoln?", I assert a desire that you tell me a to me unknown person whom I assert to have killed Lincoln.

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*Thus, given "I don't believe that Brown is ill," though indicative in form, the "is" has no indicative or assertive value. Otherwise I am in the embarrassing position of vouching for Brown's illness in the very breath in which I deny my belief therein.

ITS STRUCTURE.

The materials of the judgment (interrogative as to term or adjunct) being now collected or close at hand, it remains to be determined how they are put together.

Having, for instance, begun a judgment which, if completed, would have been expressed by "Booth killed Lincoln," I have accomplished only what may be expressed by "—— killed Lincoln." Discontented with this result, I have experienced a desire that you furnish me what shall fill the void indicated by the blank. Being unable directly to express desire itself—able only to express an intellectual operation on desire—I have formed the judgment "I believe in the truth of my desire that you furnish me what shall fill the void"—or, more briefly, "I desire you to tell me the void-filler."

As you, however, cannot know what idea is suitable to act as void-filler, except so far as I may aid you, I do the best I can, by giving you the void's mental environment, which serves you as its boundaries and therefore also as a quasi-description of the void-filler.

How this description will operate upon your mind, I shall try to show in the next-succeeding section. Meantime I note that for reasons indicated on pp. 417–420 the description itself is formed as a judgment.

I have then, as the materials of an interrogative judgment, two defective judgments (defective in so far as a term of each is ruinously indefinite) expressible by

(1) "I desire you to tell me void-filler."

(2) "Void-filler killed Lincoln."

It is obvious that what I mean by "void-filler" in one of these expressions, I also mean in the other. Also, when you come to think my thoughts after me, if you are to do so exactly, you too must hold fast to precisely the same idea in each of the judgments which you form.

Now ideas are quite unstable. If, having led you to form one in your mind, I let it slip an instant from your mental field, I cannot rely upon its reappearing exactly as it was at first. In the argument of Mr. Joseph Cook, that life continues after organization ceases, he had in mind sometimes the life of constituent cells, and sometimes the life of the constituted individual.

That is, the idea expressed by "life" was not the same at different stages of his thinking.

To avoid in your case any chance of such an accident—to make sure that in your mind the idea of a void-filler undergoes no variation—my surest course will be to form that idea in your mind once only. Moreover, as your thinking will be, so far as may be, like my own, I also restrict myself to a single thinking of the void-filler. Nevertheless, as argued on pp. 421–423, 417–420, I must somehow form in your mind both judgments—the one, that I desire you to tell me the void-filler—the other, serving to describe the void-filler.

Under these requirements, the only course I think of is the following—a course, moreover, favored by considerations of economy. Before one judgment containing the idea of the void-filler fades at all from mind, I must use that idea in the other judgment. That is, I must combine my separate acts of judging into one continuous mental operation, consisting of two judgments with a simultaneous common factor—that factor being the idea of the void-filler. The mental action, in the case of my illustration, will accordingly be indicated by the diagram

I desire you to tell me void-filler
killed
Lincoln.*

ITS OPERATION ON THE HEARER'S MIND.

Postponing the problem of sententially expressing an interrogative judgment of the present type, let it for the moment be assumed that expression is sufficiently effected by my diagram—that I do thereby succeed in revealing to you such a judgment. Accordingly you have in mind the interrogative judgment, or

*The power thus to use an idea, thought of only once, as simultaneous element of two different thoughts (a power which, in a Revision of the Pronoun, pp. 49–52 I made a somewhat protracted effort to establish) I will at present merely illustrate objectively, by the case of a north-east corner-stone, which is at the same time part of an east wall, and part of a north wall, but remains in its double membership a single stone. Indeed it seems to me it can be sensed as corner—sensed, I mean, with full appreciation—only as it is, by a single mental act, appreciated in its two-fold membership of north wall and of south wall.

say the interlocking pair of judgments, which I have sought to diagram by

I wish you to tell me void-filler
killed
Lincoln

At first sight all our effort, yours as well as mine, may seem to be hardly worth the while. The common factor of the judgments is, in a first condition of my mind, a mental zero, and later merely an unknown quantity. Now zero once is zero again; and an unknown quantity is not made known by repetition. Yet everyone remembers that the value of an algebraic x, though unrevealed by either of two equations, may some times be obtained from their cooperation. Indeed, the case presented by my diagram is to a certain extent analogous. I use an unknown quantity in each one of two judgments. In one of these I expect you to obtain for the unknown term a substitute in terms of the known—and, having done so, to use it in the other judgment. But, dropping algebraic illustration, I wish to center attention on the case in hand.

I concede that my pair of judgments would disappoint my purpose, were your knowledge no greater than my own. But what is unknown to me is supposed to be known to you. On my side the desired idea forms no part of mental stock. But on your side it is a part of mental stock. Your only difficulty is to find it—to select it from its fellows. If then, while letting you know that I wish you to tell me an idea, I successfully direct you to its selection among the ideas in your possession, you will be enabled to fulfill my wish. What needs to be established, then, is your susceptibility to such direction.

In the effort to exhibit this, I substitute for "void-filler" the convenient x, and diagram the chosen illustration of the interrogative judgment now considered, by

I desire you to tell me x
killed
Lincoln

On reading this, I assume that you admit to mind what I will call a horizontal thought (because expressed by words in horizontal series), and also a perpendicular thought. Under the in-

fluence of the latter you experience, I suppose, a mental reaction, which I wish to examine with some care, as it seems to me to give the key to the solution of the interrogative problem.

To appreciate this reaction, let it first of all be remembered (see p. 367) that every thought may be seen by the mental eye as a combination of any single constituent and a remainder. In the thought expressed by "*x* killed Lincoln," the very indefiniteness of the "*x*," antagonizing the definiteness of "killed Lincoln," tends to pose the thought before your mind as consisting of an indefinite idea and a definite remainder. This tendency is strengthened by the fact that the indefinite idea, having already served in a former thought, appears in the present thought as old material, while what is offered by "killed Lincoln" is new. In short, regarding thought as a mental unit, you specially regard the unit of the moment as made up of two sub-units, respectively expressed by "*x*" and "killed Lincoln." Of these, you probably accept the latter without disfavor. With the one expressed by "*x*" you are, I suppose, dissatisfied as much as I. Moreover each of us would like to pass to the more agreeable mood of satisfaction, as the sequel to a successful restoration of our defective mental statuary. The question is: Can you effect the restoration? I think you can; indeed, I think you must.

I continue, of course, to assume that what is needed for the restoration, is part of your mental stock—that you very well know that Booth killed Lincoln. In all your knowledge there is, moreover, no other item which can be confused with this—none such, for instance, as Smith or Brown or Robinson killed Lincoln. If then the present factor of thought, expressed by "killed Lincoln," can by any means suggest the absent factor, there is no danger of mistake; for there is nothing but Booth to be suggested.

That, in a rightly working mind, the absent factor Booth will be suggested, is, I believe, the consensus of theory and experience. Whether we say that the explosion of the brain cells which register "killed Lincoln," is followed by an overflow of energy along a well-worn channel to the cells which register Booth, exploding them, and projecting into consciousness the idea named by Booth—or content ourselves with saying that the entrance into mind of one thought-factor entails, by association of ideas, the entrance of the other factor—to you, who have already formed the thought expressed by "Booth killed Lin-

coln," the suggestion of what is named by "killed Lincoln" is enough to bring into your mind what is named by "Booth."

Accordingly, if so disposed, you answer "The slayer of Lincoln was Booth," or "Booth killed Lincoln," or simply "Booth." To me, indeed, this name may be only a name, a "vox et praeterea nihil;" and I may or may not be contented with it. If not, I can by further questions ask of you further details, which you in turn can give me, until you build up in my mind an idea which satisfies me, or until your mental supply is exhausted.

All this I neglect, as it seems to me that what I contend for is established—namely, that the interrogative judgment will effect the speaker's purpose, if only it can be revealed to the hearer. The feasibility of thus revealing such a judgment I hope to establish under the title

ITS EXPRESSION BY A SENTENCE.

In effecting this my greatest difficulty will be offered by the void-filler—what in diagram I indicated by an *x*. My mental image of this void-filler is, indeed, about as lean as may be. I have, however, considerable faith that such a void-filler there is (otherwise I should stultify myself by trying to induce you to reveal it). But that is essentially all. I cannot distinguish it from other thinkables. I cannot tell its qualities. In short it stands before my mind as substance bare of attributes, an idea, however, by no means rare in linguistic experience.

The word for naming this idea is "something," taken for the moment in its broadest meaning. Were I therefore to say that "Something killed Lincoln," the "something" might cover any one of the following: a man, an animal, an herb, a stone—an illness, an accident, an evil spirit—in short, essentially any idea that the mind may admit. "Something" is accordingly what is called indefinite, which means in the present case not merely that the word is unable to point your attention to one of many definite ideas which might be in my mind, but that the idea which is actually in my mind (expressed by "something") is in this case substance without attribute—in other words, itself as indefinite as it can be.

The indefiniteness of such an idea is usually less extreme. To the idea expressed by "something" there is ordinarily joined enough of attribute to exclude, for instance, both animal and

spiritual being. The far more special "Some one" restricts the field to persons, or even human beings. Gender inflection may still further confine it to men or to women. But within the narrowed field indefiniteness remains complete.

In such a narrowed field interrogation commonly operates. In asking "Who killed Lincoln?," the fact that the desired idea is clothed with attributes enough to fix it perhaps in the category "Man," has little practical value. I am still so far from having the idea which I wish to have, that, within my present universe of desire, I may surely go so far as to call the desired idea substance *short* of attribute or, in that special sense, indefinite.

Without examining further these and other differences between indefinites, I venture to use the "Some one" instead of "*x*," and to express the horizontal thought of my diagram by the sentence "I desire you to tell me some one."

I think it also proper to use the "Some one" in expressing the perpendicular thought. For obviously the person whom I wish you to tell me, and the person thought of as killing Lincoln, are the same. Accordingly,

I desire you to tell me some one
killed
Lincoln.

Crude as it is, this diagram appears to me to express an interrogative judgment with sufficient clearness to enable an actively cooperating and intelligent mind to find a desired idea, and to induce such a mind to tell the said idea, if so disposed. The only peculiarity of the diagram is a slight peculiarity in the use of the indefinite. From this may be inferred the conclusion, later to be reached, that every so-called "interrogative word" is based upon merely a somewhat peculiarly used indefinite.

In this diagram I note that the idea expressed by "some one," being simultaneously part of the horizontal thought and part of the perpendicular, stands in need of twice as much aid from inflection as it would require, if used in only one of its two thought-factorships. The word is on the one hand used as direct object in the horizontal sentence; and this it would be well to indicate by accusative inflection. On the other hand the word is used as subject in the perpendicular sentence; and this

it would be also well to indicate by nominative inflection. But language does not seem to furnish double inflection of the sort required by this double factorship. The linguistic expedient adopted to meet this exigency is the relative, in the present case the so-called relative pronoun "who." I therefore reconstruct my diagram, utilizing this "who" and also displacing the indefinite "some one" by the more convenient "him," which in this case is also indefinite. Accordingly,

I wish you to tell me him
who
killed
Lincoln.

This diagram I later utilize as the interpretation of the question "Who killed Lincoln?" Meantime, inspecting the operative method of the diagram in thought-expression, I find no obscurity, unless it be in the case of "who." Examining as closely as I can, I note that the idea expressed by "him" is not repeated or varied in its nature by "who." I conclude accordingly that "who" is strictly void of meaning—that is, it stands for no idea which forms a part of intended thought. Its use is that of plans and specifications, which, helpful as they are in the construction of a building, form no part of the building constructed. It may then be distinguished as instructional, but by no means structural.

Reviewing its instructional activity, I find that it warns my hearer not to allow the idea introduced by "him" to slip away from his attention, but to hold it fast in mind while a new environment of ideas is gathered around it. Accordingly, for my personal convenience, I call it a continuative. But the more important function of this "who" I take to be its indication that the idea, shown by the special form of "him" to be already the object in a first environment, is to be the subject in the yet to be assembled second environment. To me accordingly "who," in its more conspicuous aspect, is merely a "case-ending," isolated from its stem, the sign of a single idea's particular membership in one of two thoughts into which it enters. (For an elaboration of this theory, see "A Revision of the Pronoun"—Chap. III.)

Wishing further to condense my diagram, I utilize the power of multiple symbolization. Just as "what" may be invested

with the values proper to both "that" and "which," so also I force the "who" to do the double duty of "him" and "who." That is, a pregnant "who" shall be made to act as relative and antecedent both, but not completely. The idea-naming power of "him" the pregnant "who" acquires; of case-exhibiting power, it holds fast that of the merely relative "who;" but that of "him" it relinquishes. Availing myself of this still increasedly effective pregnant "who," I reconstruct my diagram, obtaining

I wish you to tell me who
killed
Lincoln.

Needing now no longer the depictive power of a diagram, I substitute the sentence

"I wish you to tell me who killed Lincoln."

This sentence, and the briefer

"Tell me who killed Lincoln,"

I regard as expressing an interrogative judgment of the now-considered genus—that is, a judgment interrogative as to a term (in the present case, the first term or subject of the insufficient prior judgment "—— killed Lincoln") or adjunct. These sentences, however, are by no means questions in the usual sense of the word. To become a question, even the briefer sentence requires further bulk-reduction; and such reduction is accomplished by what I will examine under the title

THE SPECIALLY QUESTION-ASKING WORD.

Let it be assumed that, in the illustration "Who killed Lincoln?," "Who?" is that word. This assumption I hope to justify in the remaining sections of this chapter, especially the following, devoted to

Its meaning.

Not finding the meaning of such a word as "Who?" in current definitions and descriptions, in my opinion both defective and misleading, and being quite unable to suppose a confidence in my own ability to extort the meaning from the word itself, I have assumed that, at any rate, the meaning of the total sentence of which it is a member, might be established with essen-

tial accuracy—and that, in that total meaning, the particular meaning of the question-asking word would necessarily be included.

That total meaning, reached by a priori reasoning upon the influences which mould an interrogative judgment, was, in the case of my illustration, claimed (on p. 431) to be

"I wish you to tell me him who killed Lincoln."

In support of this claim I have mainly relied on personal introspection, appealing for confirmation to the introspection of others. If a consensus has been reached, it is presumably not only gratifying, but also correct—and more surely so than I have thus far indicated; for we have been half-wittingly submitting our interpretation of the question to tests severe and numerous, derived from our linguistic experience. Of these the most conspicuous is the required agreement of interpretation with the indications offered by the speaker's gesture, facial expression, tone of voice, and by the environment of the sentence, either circumstantial or contextual—that is, objective or ideal. These, repeated thousands of times, establish the total meaning of the question, as it seems to me, beyond a peradventure.

To illustrate the force of these indications, suppose that, answering my invitation to meet me at my house, my hearer say, "I don't know but what I'll come," or "I don't know as I *will*, and I don't know *as* I will." Some of the words employed in these illustrations are quite beyond my understanding; yet I am absolutely certain of the total thought intended by either expression.

In the case of the question, I regard the absoluteness of our certainty as even greater. For I do not concede that any member of a question is beyond the ordinary understanding. If any member were so, it would doubtless be the specially interrogative word—or say the "Who?;" but even this, I believe to have a meaning, accurate and recognized. Our perception of this meaning, I suppose, like that of countless other such, to have faded somewhat, becoming rather indistinct—and largely because the interrogative act is performed so often, and so easily, that we have ceased to heed its details. In exhibiting this meaning, I shall work, however, to the best advantage by treating it first as if it were unknown, and seeking to deduce it from the known—that is, from the interpretation which I have assumed as known.

Let accordingly the question and interpretation take their places together, as follows:

"I desire you to tell me him who killed Lincoln," and

"Who killed Lincoln?"

It is postulated that the three words of the question do in some way express the total thought presented by the ten of interpretation. It is required to determine how the duties of the ten are divided up among the three.

My own opinion is that, of the three, the first is made to tell the messages entrusted to the first eight of the ten. This opinion—superficially, at least, implausible—will perhaps be rendered somewhat less so by the following considerations.

It is not extremely difficult for a single word to tell a multiple message—to stand for a cluster of ideas—provided the number and the nature of the messages be constant. Putting myself in the messenger's place, I had rather be the bearer of half a hundred messages the same from day to day, than to tell a single message daily, now of one sort, and again of another altogether different. I had vastly rather undertake the indicated business of "Who?," as agent for the bearers of eight single messages, provided that the eight-fold duty be the same from day to day, than to act as single-message carrier myself, embarrassed with an ever-changing message—such a message as, for instance, that entrusted to the sore ill-treated "post." The burden put upon that word is only partly indicated in the following sentence: "They want some iron posts at the post (military) where my brother has his post (station), and I am going to post this letter at the post (office), in order to post him post-haste as to prices." The embarrassment occasioned by such change of message is not inflicted on the "Who?" of a question. It obviously makes no difference whether I ask you "Who killed Lincoln?" or "Who stole my umbrella?" or any similar question. The message which I claim to be imposed upon the "Who?" is in every case the same.

Again, if the duty entrusted to the eight words of the interpretation "[1]I [2]wish [3]you [4]to [5]tell [6]me [7]him [8]who killed Lincoln" shall still be done when I restrict myself to the question "Who killed Lincoln?," I do not see that, in that duty, any word but "Who?" can share. Not only the ideas expressed by "killed" and "Lincoln" may be replaced by those expressed by "stole" and "umbrella," or a thousand other words, without effect upon the re-

mainder of interrogative thought; but also I cannot discover any element of meaning common to both "killed" and "stole," or to "Lincoln" and "umbrella," which might be a part of what I claim to be expressed by "Who?" Indeed, I may dismiss without replacement, "killed" or "Lincoln," or even both at once; and still I do not find that "Who?" is in this instance called upon for any increase of exertion as a messenger. In short, no part of what is meant by the eight interpreting words appears to be expressed by any word of the question but "Who?" Accordingly, if this meaning be expressed by any member of the question "Who killed Lincoln?," the expressing must be done by "Who?" alone. This is, the interrogative "Who?" must mean "I wish you to tell me him who."

A probability that any message given to the "Who?" of the question will in some way differ from that entrusted to the "who" of the interpretation, is moreover indicated by the difference in the vocal treatments of the words themselves. As merely one of ten, the "who" is uttered feebly and in a somewhat lower pitch than its fellows. As one of three, the "Who?" is uttered very differently. In the present state of vocal usage (and its explanation) I admit its general insecurity as basis for an argument; yet, for the difference in these particular vocal renderings, I think there is a rational motive, explanatory of the case in hand.

As one of ten, as a relative—that is, an isolated case-inflection—"who" is not on a par of importance with attendant fully empowered words. These are the bearers, each, of a part of the thought to be constructed—each the bringer of a special message. "Who" is the merest badge of one particular message-bringer—the indication of his rank in the embassy of thought. Properly, in such a case, this "who" is vocally subordinate.

Vocal treatment varies little when, by the use of a pregnant "who" (see p. 432) interpretation is reduced to

"I wish you to tell me who killed Lincoln."

Little variation is, indeed, to be expected, since the pregnant "who" is so much more appreciably the heir of the formally identical relative "who," than of the utterly different "him."

But when the "Who?" is one of three, becoming interrogative, its pitch and loudness equal in American English, and surpass in British English, those of any other sentence-member; and this I take to be because it bears a message even weightier than that of either fellow-messenger.

Taking a hint from Chinese, I infer that the "Who?" of the verbal trio—that is, the interrogative "Who?"—is intended as a different word from the "who" of either interpretation—in particular, the pregnant "who," whose vocal treatment is the less dissimilar. This inference is strengthened by the practice of other languages, in which the interrogative and relative (both simple relative and pregnant relative) are given altogether different forms, and ranked as absolutely different words. As such, there is ground for expecting them to show a difference in their values.

By "value" I intend not only meaning—that is, (1) contribution of thought-elements—but also guidance—that is, (2) contribution of knowledge how thought-elements are to be put together. Value, in other words, shall stand for thought-contingents of two kinds, structural and instructional—the latter being extra-structural. (See p. 431.)

As for differences of meaning in the sense of (1), I noted on p. 432 that the pregnant "who" has only the meaning of the indefinite sometimes antecedent "him," which it has incorporated. On the other hand the interrogative "Who?" has all the meaning of "I desire you to tell me him (or the person)." In a search, exhausting if not exhaustive, I have discovered nothing more. This total—big enough, no doubt, without expansion—I believe to be what is meant by "Who?" I cannot see that it is merely inferred, or say supplied. I believe that, when I use the interrogative "Who?," I regularly think, though doubtless somewhat dimly, of what is expressed by "I desire you to tell me him;" that I wish you also to think of the same; that I succeed in bringing you to do so. Believing thus, I must rank what each of us regularly thinks of, as actually expressed by "Who?"—as what indeed the dictionary should exhibit as its meaning.*

As for differences in guidance, I find none. The power entrusted to the pregnant "who" is handed over to the interrogative, it seems to me, intact. To make this clear, compare

*I was myself somewhat dismayed, at first, by this result of a quite uncompromising argument. I venture however to hope that those who must regard a part of this meaning (of Who?) as inferred, can charge up to an unimportant "personal equation" what they deem excess of meaning proper, without regarding my conclusions as otherwise invalid.

(1) { "I wish you to tell me him who killed Lincoln" and
"I wish you to tell me him whom Booth killed."

The indefinite "him" is, in each expression, shown by the form of "him" to be the object of "tell." Whatever is meant by "him" is, however, in the one case, shown to be also the subject of "killed"—shown, in the other, to be also the object of "killed." These latter showings are respectively effected by the relatives "who" and "whom."

In

(2) { "I wish you tell me who killed Lincoln" and
"I wish you to tell me whom Booth killed."

the guidance, offered in the previous illustrations by the merely relative "who" and "whom," is still afforded by the "who" and "whom," now pregnant. But the guidance, offered in the previous illustrations by "him," is no longer given.

Let now the last expressions be replaced by formal interrogations. Accordingly,

(3) { "Who killed Lincoln?" and
"Whom killed Booth?" (or "Whom did B. kill?").

Plainly the showings effected by the pregnant relatives of (2) are effected also by the interrogatives of (3). That is, in addition to its meaning already noted, the interrogative offers guidance in the form of warning that an idea, already used as factor of one thought, is to continue in attention, while further ideas join with it in forming another thought; and the said idea's particular factorship in that other thought, the interrogative (e. g. "Who?") distinctly indicates.

Moreover I do not see that, in the matter of guidance, the interrogative exhibits any addition to the power possessed by the relative and the pregnant "who" alike. Recapitulating then I find in the interrogative "Who?" the guidance offered by the relative "who;" but, instead of the no meaning proper of the relative "who," I find in the interrogative "Who?" the very bulky meaning expressible by "I desire you to tell me him."

I am far from claiming that the interrogative word was, strictly speaking, derived from the relative. The former means to me too much, and the latter too little, to encourage such a theory. Moreover, at the date of developing the interrogative word, it remains to be proven that the language-maker found the relative word in existence; and in some languages he never found it. That in many languages he

would find a word predestined to become a relative, is obvious; but he might find it in a stage of development at that time only indefinite, and not yet advanced to relative rank. To me the relative and interrogative are collateral descendants of the indefinite. My purely personal guess, indeed, is that the interrogative antedates the distinctly relative word.

Values of other interrogative words may be outlined as follows.

"What?," in the sense of the German "Was?"—indefinite as to kind and individuality, but commonly not as to number—means "I wish you to tell me that (which)." As for guidance, it directs the hearer to continue in mind the thought-factor expressed by "that," and to use it as a factor (not specified by its form as subject or object) in a sentence yet to come. E. g. *"Tell me that (which)* killed Lincoln."

"What?" in the sense of the German "Welcher?"—indefinite as to individuality but not as to kind or number—may be illustrated by "What actor killed Lincoln?" This I interpret as meaning *"Tell me the* actor (distinguished from others by having killed Lincoln, i. e.) *who* killed Lincoln." In this expression "the," though commonly known as definite article, stands for what is in my thought decidedly indefinite, serving only to suggest that category of particularity, which I am unable to fill. I am virtually asking you to fix that individuality to which I can make no nearer approach than by saying *"An* actor killed Lincoln" or *"Some* actor killed Lincoln." With this stipulation, I interpret "What?" as meaning "Tell me the . . . who."

As to guidance, the fact that "the" is adjunctive to an object of "Tell," is overlooked. The fact that "who" will figure as subject (or object) in a following sentence, dominates. Accordingly when inflection exists, as with "Welcher?," it indicates the function which the object of "Tell" shall have in the following sentence.

Plainly "What?," in such a usage, offers systematic grammar opportunity to recognize an interrogative *article.* For a *relative article* conf. "An actor—*which* actor for the time escaped—assassinated Lincoln."

"Which?" in many usages is like the just preceding "What?," except that commonly a somewhat smaller group is contemplated, indefiniteness of individuality being thereby correspondingly

reduced, as in "Which Booth (i. e., which member of a family) killed Lincoln?"

"Whether?" (obsolescent) merely reduces the scope of undetermined individuality to a pair of terms—e. g. "Whether of the two (the older and the younger Booths) killed Lincoln?"

"Qualis?"—indefinite as to attribute—specially deals with attributes of substantive ideas, being accordingly, in one of its simultaneous functions, ranked as an adjective. To illustrate, "Qualis est Julius?" I interpret as meaning "Tell me the attribute—or quality—(which) Julius is characterized by."

In reducing this expression to the form "Qualis est Julius?" I note that we might, if we chose, say "Tell me the quality (which) characterizes Julius," thereby reducing thought and expression to already considered types. But instead of doing so, we adopt the thought-form expressible by "Tell me that (substantive) which (adjective) Julius is."

This use of a single idea, as *simultaneously* substantive in one thought and adjective in another, may be led up to by the exhibition of *successive* substantive and adjective function, which though little observed and less commended, is nevertheless a linguistic procedure by no means rare, and, as it seems to me, by no means unwarrantable. Thus, following the statement that "Her dress is *red,*" I do not hesitate to use the expression *"That* is a beautiful color," passing without warning from adjective to substantive use of an idea. The converse change, though more uncommon, is hardly subject rationally to any harsher criticism. Accordingly, having said that *"Red* is a beautiful color," my linguistic instinct will not be severely shocked, if I get the answer "My party-dress is *that.*" Indeed, instead of two appearances of one idea in functions successively substantive and adjective, I may encounter the idea in a single appearance, but as simultaneously factor of two thoughts, in the first of which it is substantive, while adjective in the other. This will happen if the answer be "That's the color my dress is," meaning "That color is the color (substantive) which (adjective) my dress is."

Simultaneous different functions are indeed a foregone conclusion, so soon as thought develops some complexity. For, granted that an idea is to serve as factor in each of two idea combinations, it is not to be expected that it should hold in each precisely the same position—that its rank in one should always tally

with its rank in the other. "Verbal nouns" and "verbal adjectives" are witness by their very titles to the difference of simultaneous functions. Admit the neglected "adjective noun" and the present case is covered. Thus, in "Her dress is bright red," "red," in its fellowship with "dress is," ranks as adjective; but as term to the adjunct "bright" the same "red" must pose as substantive. (Conf. "Studying lessons aloud is forbidden," etc.)

Accordingly, interpreting "Qualis est Julius?" as meaning "Tell me what (=that which) Julius is," I define the "Qualis?" as meaning *"Tell me that* (substantive) *which* (adjective) . . . . ."

In guidance, as with "Welcher?," the first of the two functions is neglected, the case-ending being used to indicate the second.

"Where?," "Whither?," "When?," "How?," etc.—indefinite like "Qualis?" as to attribute—have special dealing with the attribute of a verb. Neglecting such a question as "Where is Brown?", in which location is presumably rather predicate adjective to "Brown is" than adverbial, I elect as typical the sentence "Whither go you?" This I interpret as meaning "Tell me the direction which characterizes your going." But instead of using thought of the form thus indicated, we commonly substitute the form expressed by "Tell me the direction (substantive) which (adverbial) you are going."

This use of one idea in simultaneously substantive and adverbial functions may be familiarized by the sentence "What surprises me is the *little* you are influenced by your friends."

I forbear to tax already wearied patience with my own interpretation of other specially question-asking words, or the legionary cases of their usage in distorted thought-perspective, e. g., "How old a man did you meet?", instead of "What was the age of the man you met?" Nor shall I seek to determine what parts of speech may be embodied in the interrogative words. It is obvious that any element of any, the most complex, thought may utilize its fellows as a description of itself—that any element, thus described, I may ask you to tell me; that is, any element may form the nucleus of a question; that is, again, the way is open for each one of the parts of speech to develop an interrogative form. The actual non-development of some is merely one of many linguistic inactions to be explained by the absence of sufficient action-causing motive. The interrogatives which language actually has developed, suffice, with a little ingenuity, for all linguistic needs. Suppose, for instance, that I do not know whether my grammar is on my reader or under it, before it or behind it, "rechts oder links."

In short, the prepositional idea is absent or indefinite. Having no interrogative of prepositional aspect, with which to ask your help, I reconstruct my thought in such a way as to bring the space relation which a preposition commonly renders, into such a region of my thought, that I can express it by a substantive. Accordingly, "The position (space relation to my reader) of my grammar is what?" or "What is the position of my grammar?" Again, not knowing the action in which Booth was actor and Lincoln actee, and not possessing an interrogative symbol for it—say an interrogative verb, as in "Booth *whatted* Lincoln?"—I generalize the action under the symbol "do," and formally particularize it as "a doing something;" and this something I make the nucleus of a question, using the expression, "What did Booth do to Lincoln?" meaning, "Tell me something Booth did to Lincoln."

Precedents for bulky meaning.

That a single word should have the total meaning commonly expressed by many, need occasion no surprise. In the beginnings of speech the single word is believed to have performed the duty now-a-days assigned to the sentence. Indeed, survivals such as "Pluit" are familiar. Looking for illustration nearer home, suppose you ask "Did Booth kill Lincoln?", and I answer "Yes." My single word is conceded to express as much as "Booth killed Lincoln." By reinstatement it assembles what ideas I need, and adds to them what is further required, to form a judgment. The monosyllable "Come!" is generally held to assert whatever is asserted by "I desire you to come." Meaning is not less multiple or complex in the sentence "Please!" (Conf. pp. 434, etc.)

The sentences, however, thus far cited, do not appear as parts of larger sentences. For such as do, I look to other languages. "Un je ne sais quoi me trouble" means "An I-do-not-know-what-it-is agitates me." Examining the meaning of this group of words, employed in French to express the subject of intended thought, I find they form a sentence, while serving at the same time in a larger sentence precisely as a single word. Indeed, they form an available definition of "quelque chose," "(et)was" or "something."

Its rank.

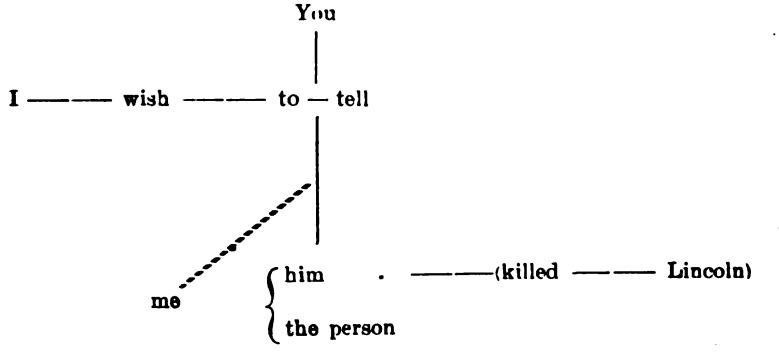
In examining the "relative pronoun" I was forced to conclude that it is not, in any proper sense, a pronoun—that, in the ordinary sense, it is not a word, because it does not stand for any element of thought—that it is merely a sign that an idea, already named by its antecedent and put thereby in one environment, is to remain in mind while a second environment gathers about it—commonly also a sign that, in this second environment, the said

idea is to serve as a particular thought-member. I called it, in this last symbolic activity, an isolated case-ending, the sign of a second case-usage.

Of the interrogative I also claim that it is not a pronoun, and that, in the ordinary sense, it is not a word—not however because it means too little, but because it means by far too much. To call it on the other hand a sentence, ranking it with "Yes" or "Pluit," may at first sight seem improper; for it offers more than even these. This more, however, I have sought to exhibit as not a more of meaning, but merely a more of what do with meaning. So far as meaning only is concerned, I claim for "Who?" an exact equivalence to "I wish you to tell me him." That is, I claim that "Who?" is a sentence*—strictly no more—surely no less.

From its fellow one-word sentences, I differentiate the "Who?" as follows: Condensing the expression of its total

*The judgment expressed by this sentence has a first term "I", a mid-term "wish" and a last term "to tell". (See diagram below.) This last term is moreover mid-term in a second environment. In this, the "you" appears as first term of "to tell." Of last terms there are two, one direct and the other indirect; for the current of the action has, like that of many rivers, a lateral effluent. The indirect last term is "me"; the direct is "him", with the formally definite but substantially indefinite meaning of "the person". Following the hint afforded by the relative power which abides in the interrogative "Who?" I perceive that "the person" is to serve as subject in a new environment, yet to gather about it. Supplying such an environment, I find "the person" further used as first term to a mid-term, e. g., "killed", and a last term, e. g., "Lincoln", which together act as its restricter. Diagraming I accordingly obtain



value (structural and instructional) from "I wish you to tell me the person (him) who" into "Tell me the person who," I see that it should rank as an imperative sentence. I further note that the idea named by "person"—that is, a part of the meaning of "Who?"—is to serve, without an intervening disappearance from attention, as particular factor (subject) in a coming thought—a thought expressible, for instance, by "the person killed Lincoln." Generalizing on my observation, I rank the interrogative word as ordinarily a one-word imperative sentence, one factor of which is signalized as also simultaneously a particular factor in another sentence yet to come.

The ordinary value of the interrogative word is often reduced, such word renouncing the indication of *particular* second factorship, as in "What killed Lincoln?" (that is, "I wish you to tell me that which killed Lincoln") an expression in which the interrogative "What?" does not announce its indefinite element "that," as either subject or object of "killed."

The ordinary value of the interrogative word is also sometimes much augmented. For instance, when used alone, as sequel to a statement such as "Some one killed Lincoln," the "Who?" alone not only means "Tell me the person (,him)", but also (with a power now for the first time strictly pronominal) reinstates ideas expressed by "killed" and "Lincoln." That is, the "Who?" has all the meaning of the expression "Tell me the person (,him) killed Lincoln." In such a case the so-called interrogative word should rank as a pair of sentences with a simultaneous factor marked for particular service in the second sentence.

To ask 'What part of speech is "Who?"' must therefore seem to me an idle question. This "Who?" is not a part of speech, but as others, I think, have said, a speech in itself—the presentation of a thought which is always complete in form, and, in the case last noted, complete in substance also. With still broader generality it may then be concluded, that the interrogative word is the linguistic equivalent of always one and sometimes both of a pair of sentences linked by a factor signalized as simultaneous, and often marked for a particular service in the second sentence.

CHAPTER IV.

THE JUDGMENT INTERROGATIVE AS TO BELIEF.

Part of the reasoning which I bring to bear upon the interrogative problem, in the aspect now to be considered, is so close a duplicate of that already followed in preceding chapters, that it need not be repeated. The remainder may be introduced by the illustration: "Are you coming?—because I have to make my plans accordingly."

Assuming my interpretation of these words to be that of everyone, I note that what follows the question "Are you coming?"—namely my necessary planning, or my need of planning—is the cause, as seen by me, of whatever I mean by "Are you coming?" Accordingly, to find out what my need (in my opinion) causes, is to find out more or less completely what is meant by "Are you coming?"

Examining the words of this question, if I give them only the meanings which they have in extra-interrogative usage, I obtain at the most a conception (which may be expressed by "your coming") plus, it may be, a personal conviction of its truth; but this conviction, in the present case, is plainly not intended. Let it therefore be excluded. What is left—that is, "Your coming"—is obviously by no means what my need of planning causes. Accordingly I have not thus far discovered what my need of planning causes.

That my need however causes something, must be regarded as my own opinion, since I use the word "because." Moreover I am sure I know right well just what, as seen by me, it causes—namely, a desire to know whether you will come or not. Which one of the two you do, is comparatively unimportant, provided only that I know which one it is going to be. Now this I hope to know as the result of information to be given by you. Thinking dominantly then of your primary informing, rather than of my own thereby to be developed secondary knowing, I experience my desire as a desire that you tell me something—some-

thing which of course requires telling—something which, without your telling, is not in my mind. This something, as preeminently part of interrogative judgment, I examine under the general title of

ITS ELEMENTS

and, in its primary aspect, under the special title of

The missing element—belief.

The examination of this may begin with the classification of essential judgment-elements (brought forward from Chap. I) —which alone I propose to consider—as

(1) Primary or essential elements of thought (or conception), i. e., first term, mid-term or relation, last term;

(2) Truth or untruth of the thought consisting thereof;

(3) Belief in such truth or untruth.

In the judgment which the now considered form of question aims to make sufficient, all terms of (1) are present. To exhibit this, I choose an illustration in which the mid-term is expressed by the word "to-be." For, although this mid-term or relation is somewhat embarrassing by reason of its vagueness, this word has the advantage, in the now considered usage, of avoiding that even more embarrassing auxiliary which appears in such a sentence as "Does A equal B?" or "Did Booth kill Lincoln?" * Accordingly, "Is Brown honest?"

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*In the question-asking sentence of the type considered in this chapter, it has been claimed that the question-asking power resides in "Does" or "Did." Among the many reasons why this claim should be disregarded, I note that no more interrogative force would seem to reside in "Did," than might be claimed for other so-called auxiliaries in "*Was* Booth killing Lincoln?", "*Has* he killed him?", "*Will* he kill him?" or even "Whom *did* he kill?", although in the last expression the supporters of the "Did" hypothesis agree to put the interrogative burden on the "Whom?"

Moreover, other languages in general have no word like "Did;" and even in English its aid is abrogated in poetic or exalted diction—for instance, "Saw ye him whom my soul loveth?" (Cant. III, 3). Accordingly the expression "Did Booth kill Lincoln?" should be ranked, I think, as merely a local and fortuitous variation from the prevalent interrogative type exemplified in English by "Killed Booth Lincoln?"—a variation obviously explainable by whatever principles be found explanatory of the norm.

By this question I am plainly trying to find out something about Brown's being honest; that is, a thought expressible by "Brown to be honest" is merely part of an intended larger mental structure, say a judgment. This part contains however all that is required of it, regarded as a mere conception, i. e., a first term and a last term named respectively by "Brown" and "honest," and a mid-term or relation named by "to-be"—a relation which may be known as that of substance to its own attribute. Further detail might be added, but none is indispensable to formal thought-completeness. Accordingly the missing judgment-element is not an essential element of a conception.

The remaining judgment-elements which may be missing, are truth or untruth of thought, and belief. Examining first the former, I juxtapose the expressions "Brown to be honest" and "Brown not to be honest." Of these, the latter presents a mental picture, as if it were unmatched by reality external to itself. That is, the thought expressed is put in the aspect of untruth. Such being the case, as argued on p. 385–386, I conclude that the antagonistic "Brown to be honest" expresses a thought appearing on my mental stage in the antagonistic aspect of truth; that I intend it to appear on the mental stage of my hearer in that aspect; that my intention is realized. And what I claim for the expression "Brown to be honest," I also claim for the expression "Is Brown honest?," antagonizing it with "Isn't Brown honest?" That is, I succeed in establishing in your mind the thought of "Brown's being honest"—attended, as in my own, by its truth. (See however pp. 451, etc.) I conclude accordingly that, in the judgment which the present form of question aims to make sufficient, all elements are present, except belief.

Belief is absent. Were it not absent, the occasion for a question would itself be absent. An interrogative status would not develop in my mind. What would develop would be expressible by "Brown is honest," or more fully by "I believe in the truth of Brown's being honest." That is, I should form an affirmative judgment. As I cannot do this, I conclude that what is absent from such judgment is belief—a belief which, if present, would bear upon the truth of Brown's being honest (or, in a negative judgment, upon the untruth of Brown's being honest).

It is obvious that also disbelief is absent from the mind. Its absence however is not felt; for its presence was not planned for, any more than that of fear or gladness. Considering the judg-

ment-void as the void in a judgment intended—a judgment linguistically restricted to belief in truth or untruth of a thought—I hold that in the speaker's consciousness belief alone is missing.

The desideratum—belief-or-disbelief.

In making the desideratum cover that very disbelief so carefully excluded from assertion, there is a seeming inconsistency, which may however be relieved as follows:

If the argument conducted on p. 421 be correct, assertion—that is, the expression of belief that a thought is true (or untrue)—antedates interrogation. To this proposition it is the merest corollary, that, before interrogation is attempted, the practice of assertion develops what may be called an assertive mental habit. It is then quite conceivable, that the special form assumed by the judgment interrogative as to belief, will not be determined solely by desire for information, but will also be affected by the operative method of assertion. That it is in fact so influenced—and that most oddly—may appear as follows.

In following the assertive method, I form a mental picture—say a mere conception—in the expectation of believing, therefore discarding disbelief. I expect to believe that my picture is true, or else untrue. Sometimes however my expectation comes to naught; and at these times it is, that I ask a question of the order now considered, e. g. "Is Brown honest?" That is, as the result of being disappointed in my expectation to believe, I develop a desire that you make good my failure. The special mental form of what I desire you to do, is accordingly determined for me by my disappointed expectation—is cast in the mould of a belief arrested in development. To change my figure, the question must be studied as an effort, so to speak, to float a stranded assertion; and much depends on when the assertion runs aground.

(1) It may be that, having formed a mental picture, and contemplated its possible truth and untruth, I feel exactly equal inclinations toward the two, but no preponderating inclination—or say propension—toward either one. That is, my failure to believe the one or the other is a consciously double failure.

Suppose that, in this mental state, I appeal to you for aid. This aid you might afford, if I should set before you the two alternatives (truth and untruth), both of which I fail to believe,

and invite you to name the one believed by you. This indeed I can easily do by means of interrogative words of the type already considered, propounding such a question as "Which of the two, the truth or the untruth of Brown's being honest, do you believe?," or "Whether of the two, that Brown be honest, or that Brown be not honest, do you believe?" Indeed, when both alternatives are somewhat equally distinct in consciousness, such forms of speech are actually employed, being known as double questions. These moreover often are reduced by ellipsis, serving thus as virtual questions of the single type.* They may however be neglected, as introducing no principle new to the interrogative syntax examined in Chap. III.

(2) It may be on the other hand that, having formed a mental picture, and contemplated its possible truth and untruth, I feel a propension toward the one or the other—say the truth. This propension—strong enough perhaps to give promise of becoming full belief—may so preoccupy me, that I quite neglect the alternative untruth, letting it slip from my attention. It may however happen, that the promise fails to be fulfilled—that my propension does not grow into belief. In that event I am brought again to a mental stand-still, but somewhat later than in the former case; in other words, the mental structure which I have begun, though uncompleted, has reached a stage more near completion. As in case (1), so also in this case, I have failed—but with this difference: in the former case my failure was consciously double; in this case it is consciously single. That is, I am aware of failing to believe only a mental picture's truth.

If now you are to help me, you must do better than I have done. By dint of greater mental power, or greater knowledge, you may perhaps succeed where I have failed—that is, in believing truth. But on the other hand it may be that you cannot succeed, except in what I did not try—that is, in believing untruth, or else in disbelieving. To give you all the chances of succeeding, I must reopen choice, either between believing truth and believing untruth, or else between believing and disbelieving.

That I do not do the former, is indicated by the coexistence of the question forms "Is Brown honest?" and "Isn't Brown honest?," in one of which Brown's being honest is put in the

*Compare the Latin "(utrum)—an," and the German "ob—(oder)," etc.

single aspect of truth, while in the other the single aspect of untruth is elected. Accordingly the only course available is to reopen for you the choice between belief and disbelief. That is, I must violate what I have striven to establish as a fundamental law of assertive thinking—a violation into which I seem to have been led by the very impulsiveness of my effort to conform.

Accordingly, in asking you a question of the present order, it must be that I invite you to form for me a mental structure consisting of a thought like mine, presented like my own in the aspect of truth (or it may be untruth), and augmented by belief or disbelief therein. What this augment will be, belief or disbelief, I do not know; but, whichever it be, it is what I particularly wish to learn. Accordingly my desideratum, if once obtained in the form requested, would prove to be your belief or else your disbelief.

Meantime the desideratum stands to me for whatever is meant by belief and also whatever is meant by disbelief, being merely an indefinite of no extraordinary type. Thus, proposing to settle by a thesis, whether strikes are advantageous or the contrary, I present both attributes by a single indefinite word, in the title "The Advantageousness of Strikes." That an equally effective symbol for both belief and disbelief, will offer at the proper moment, I do not doubt. Meantime I content myself with expressing the desideratum of the interrogative sentence by the phrase "belief-or-disbelief."

Description of desideratum.

That the desideratum needs to be described, may be argued, in a general way, essentially as on pages 415–416. More specially, I note that, in addressing you a question of the present kind, I am not moved by any curiosity about your mental attitude as such, be it present, past or future. That you did or do or will believe, disbelieve or doubt—hope or fear—like, desire, purpose or the contrary—is nothing, of itself, to me. Otherwise I might ask you such a question as this: "How do you feel about your thought of this moment?"—or, more relevantly to the present case, "Which of the two, *belief* or *disbelief*, are you experiencing at this moment?"—or "did you experience at half past three yesterday afternoon?" To me it plainly makes the utmost difference what it is that you believe or dis-

believe (to be true or untrue); and all that I care to know is the mental reaction which you experience when confronted with a thought the duplicate of mine. That is, I wish to know your belief or disbelief in a particular thought—accordingly, a particular belief or disbelief, distinguishable from others by its being experienced in the presence of a particular thought. In a sense then my desideratum—that is, your belief-or-disbelief—requires description; and description is accomplished by the exhibition of the thought, belief-or-disbelief in which you are to experience. The exposition of desideratum seems then predetermined as the nomination of a belief-or-disbelief which, in the presence of a particular thought, you are to experience. The nomination of belief-or-disbelief is indispensable, because without it you might suppose my desideratum to be some other mental reaction of which you are capable—for instance, hope, fear, joy, distress, etc. The expression of the thought in which your belief-or-disbelief is to be experienced, is also indispensable, because without it you might tell me some belief-or-disbelief in which I have no interest. Accordingly, to satisfy the desire which my question aims to realize, I must not only name my desideratum, belief-or-disbelief, but also restrict, describe or define it, by adding the thought on which it is to operate.

Assertion of description.

The little which I have to say upon this topic will be said to best advantage on pp. 455–456.

Desire to be told desideratum.

Under this title I have nothing to add to arguments advanced on pp. 420–421, from which I concluded that a question must be understood as distinctly announcing the speaker's desire to be told the required conception-element of the judgment which he has vainly sought to form.

Assertion of desire.

Argument supporting such assertion would essentially repeat considerations indicated on pp. 421–423.

Truth instead of untruth and vice versa.

In forming an interrogative judgment of the present type, I have argued that I am somewhat nearer to believing the truth

of a prior conception, than I am to believing its untruth (or vice-versa). It might accordingly be expected, that I should present my thought in the dress—or say the aspect of truth or of untruth—in which it more attracts my belief. This, however, is precisely what I usually do not do. In the expression "Brown is honest, isn't he?" I am so near to believing the *truth* of Brown's being honest, that I even risk a tentative assertion. Following this with a more seriously intended question, I ask you to express yourself upon the *untruth* of Brown's being honest. In "Brown isn't honest, is he?" assertion and question are equally antagonistic. It appears then that, if I more incline to the truth of my thought, I put in question its untruth, and vice versa.

Why I do this, I do not claim to know, though several motives are conceivable. For instance, it is obvious that, in putting my thought before you in one only of its possible aspects (as true or as untrue), I expose it to a virtual contradiction by your answer. Such being the case, I may rather naturally prefer to imperil that aspect of my thought, whose contradiction will the less distress or mortify me.

Again, that aspect of my thought which I myself find less alluring, has presumably the lesser chance of satisfying you—the greater chance of rousing your antagonism; and in the latter lies perhaps my gain. I suppose that a statement such as "Two and two are five" is more likely to evoke an expression of your opinion, than the more acceptable "Two and two are four." The exhibition of the less attractive aspect of a thought, accordingly, might be defended, as an interrogative expedient, on the ground of its major effectivity as provoker of an answer.

Such explanations regard the speaker's action as a choice. Some ground, however, may be found for ranking what occurs as quite involuntary. As there forms in mind a thought consisting of the elements expressible by "Brown," "honest" and "to be," before belief arrives upon the scene, at least in all its fullness, one of the alternatives (truth or untruth) develops in me some propension toward itself. By just so much, however, as I lean toward one alternative, I lean away from the other. If belief develops, it finds the one in the very focus of the mental eye—the other in the margin of the visual field. Perhaps belief is nothing more than the focalization of one alternative, and the final disappearance of the other from the mental

view. The usages of speech, however, indicate that, whatever be the actual mental process, it is conceived by the language-using mind as first, the posing of two alternatives, and second, a siding with one of them. Doubtless, however, the neglected alternative does not disappear beyond recall. Should its presence become more welcome, it can reappear. It may be described as standing just across the threshold of consciousness, waiting its opportunity to reenter. This opportunity seems to me to come. Of two occupants of my mental field, I was impelled at first to hold to the one and despise the other. In the instant of my disappointment comes a strong revulsion. For a moment I feel the reactionary impulse not only to despise the one, but also to hold to the other. It is nothing new in the history of inclinations, if that other, taking advantage of my momentary pique, possess me quite completely—for a moment. If now it be at just this moment, that I shape my thought for the interrogative act, it will be the at the outset less attractive of my two alternatives, that will be offered to my hearer.

These explanations I wish to be understood to put forward as mere suggestions, more in the hope that they may lead some other person to the proper explanation, than in any faith that they themselves are adequate. I believe that all the noted influences are operative; but frankly, I distrust their sufficiency. Fortunately they do not seem to be needed in the solution of other interrogative difficulties.

ITS PECULIARITIES.

Among these, which might include the interchange of truth and untruth, just described, I note in the first place that it

Fails to distinguish belief-or-disbelief as meum or tuum.

By this title I mean to indicate that belief-or-disbelief is virtually dissociated from a particular believer—you or me. To recapitulate, I am blocked in the effort to form a judgment—a judgment which, if completed on lines begun, would be *my* belief in the truth (or the untruth) of a particular thought. In my embarrassment, I wish you to exhibit the element which would correspond in your mind to the void in my own, supposing you to build with my blocks, plus one which I do not

have. This corresponding element being unknown to me, I can conceive it only vaguely as a belief-or-disbelief, at some time to be experienced by me, but in the mean time experienced by *you*. The situation is, accordingly, rather intricate. I do not doubt, indeed, that language can be made to deal with it distinctly and completely. But I do extremely doubt whether the game would be worth the candle—whether, indeed, the candle could have been supplied by the earlier players of the game. It seems to me that the believing I and you are retired from the fore-ground of consciousness to such a distance, that they are no longer separated by the mental eye. So far, at least, as further examination is concerned, I think that any consciously differentiated I and you may be regarded as automatically interchanging when required, without the need of special symbols—without, indeed, the need of special recognition.

Expects answer in terms of belief only.

In my own attempt to form a judgment—say upon the honesty of Brown—I recognized that, in the condensed assertion now considered, disbelief is barred by linguistic practice—that I must choose between belief in truth of thought and belief in its untruth. Neglecting say the latter, the only course remaining open to me was to believe the truth; but this I could not do. Turning to you for help, and realizing that you must in some way be free to approve or disapprove my thought, I ignored linguistic bounds, inviting you to express your belief-or-*disbelief*.

Now if it happen that belief is that which you in fact experience, you can carry out my programme. But if it happen that you disbelieve, you cannot. That is, while, in condensed assertion, you can express belief, you cannot express disbelief. Indeed, I have no expectation that you will. I am after all aware of your linguistic limitation. In case you disbelieve, I appreciate that you will reconstruct your judgment into a belief in the truth or untruth of my offered thought. Thus, to my question "Is Brown honest?," I expect that you will answer either "Brown is honest" (or an equivalent), meaning that you believe in the truth of Brown's being honest, or "Brown is not honest," meaning that you believe in the untruth of Brown's being honest. That is, although in my embarrassment I ask an expression of belief-or-disbelief, I expect in answer only the

expression of belief. Or, vice versa, although the question of the now considered kind expects and even aims to obtain its answer in the form of a belief that a particular thought is true, or that it is untrue, nevertheless such question actually invites a belief or a disbelief in a thought already posed as true, or a thought already posed as untrue.

ITS STRUCTURE.

Reviewing the mental operations which lead to the now considered form of the interrogative act, I find that, in attempting to form a judgment, although I successfully assembled all materials of a mere conception plus its truth, I was unable to add that belief or disbelief, which is indispensable to a judgment; that, from the perception of a void in my would-be judgment, I passed to the imagination of a void-filler formable, though not by me, presumably by you; that this void-filler was necessarily indefinite; that, from the scope of this indefinite, I excluded fear, liking, purpose and other mental attitudes which might be taken by you toward a thought, reducing the scope of the indefinite to belief or disbelief; that this belief or disbelief, to be of use to me, I felt must be experienced by you in the presence of a thought the duplicate of my own; that finally I wished you to tell me this belief or disbelief.

Before attempting an interrogative sentence, I must build, as what it shall express, a mental structure—a somewhat complex interrogative judgment—which shall resume the scattered mental acts described.

In doing this, I note that, from every point of view, the most important element of my interrogative judgment will be the judgment-element with which I expect you, so to speak, to fill the void in my first attempted, unsuccessful judgment—that is, belief or disbelief experienced by you. As I do not know which one of the two you will actually experience, I can picture it only as indefinitely one or the other. As first constituent then of my interrogative mental total, I bring in what may be expressed by "belief-or-disbelief experienced by you"—or, more simply, "your belief-or-disbelief."

As this belief-or-disbelief must be the one which you experience under the influence of a particular thought conceived as

true (or else as untrue), you need this thought to furnish you that influence. Therefore I bring in this thought. In the chosen illustration, my interrogative mental structure becomes accordingly, as thus far developed, what may be expressed by "your belief-or-disbelief in the truth of Brown's being honest."

This belief-or-disbelief I obviously wish you to tell me. This wish accordingly I also bring in, completing my interrogative mental structure, which may be expressed by "I wish you to tell me your belief-or-disbelief in the truth of Brown's being honest" —or, more conveniently to further argument, by "I wish you to tell me your believing-or-disbelieving the truth of Brown to be honest."*

This expression I propose as exhibiting my thought in a form which it may assume, unbiased by the exigencies of adopted linguistic methods. Such thought, however, is apparently somewhat modified, before a sentence is attempted. I do not mean that modification is necessary; for no doubt that expression, though offered merely as a broad description of my mental state, is also quite available as it stands, for practical linguistic purposes. It suffers, however, from undue length. Condensation is to be expected. In preparation for the condensation actually reached by the interrogative sentence, modification seems to me to occur as follows:

In the first place, a judgment is substituted for the mere conception indicated by "believing-or-disbelieving, etc." As previously argued, the current judgment-forms of speech are highly condensed—more so, I think, than any others. To remodel conception into judgment, promises then the best of chances to condense.

The judgment contemplated is your own, not mine. But

*It is plain that I might resort to the expedient of analyzing your indefinite mental action (believing-or-disbelieving) into a comparatively definite doing of something indefinite. I might by this means change my interrogative judgment into the form expressible by "I wish you to tell me something (i. e. that which = what) you think of the truth, etc." This judgment I might express by "What do you think, etc,?" Similar analyses would enable me to utilize other interrogative words examined in Chap. III. For instance, interrogative ends would be met by "What opinion have you, etc.?" or "How do regard, etc.?" Enough, however, that I may and often do elect the special form of interrogative judgment indicated just above.

I can not form the judgments of other people—only my own.* But, again, in the present case I cannot form a judgment of my own. That is, I cannot really believe, or disbelieve. In this strait, I resort to a linguistic fiction. Though in fact I *neither* believe nor disbelieve, I put it that I *either* believe or disbelieve. This presentation, though strictly false, is practically harmless, as it does not favor any particular untrue thought. I am moreover naturally disposed to make it, as it merely looks beyond my actual indecision, to decision which, by your aid, I expect to reach. I offer then, as mine, what is already mine in wish, and is expected in a moment to be really mine. Moreover I am not in any danger of deceiving you. It is plain to you that I am merely putting myself in your place—merely making for you a show of that judging which you will really achieve. Without haggling over the "I," you put yourself in my place—that is, you substitute yourself for me as judgment-former—the "I," which stood for me, now symbolizing you. That is, as indicated once before (p. 452), we sink the difference between "meum and tuum."

Developing now a little the argument of p. 449, I note that the use of an indefinite "believe-or-disbelieve" may seem less implausible, if it be remembered that, after all, it is quite analogous to what was done in leading up to recognizedly interrogative words (p. 430). When I formed the imperfect judgment "..... killed Lincoln"—imperfect through the absence of a primary judgment-term—I provisionally filled the void with an indefinite "some one." So also now I fill the void created

*I could form indeed a judgment to the effect that you have formed (are forming or will form) a judgment—that is, I could form a belief that you believe a thought to be true; and such a judgment I could express by a sentence, e. g., "You believe Brown to be honest." Such a judgment also I might effectively handle as a constituent element of the interrogative judgment. But I could not find for it, in any language that I know of, a condensed expression like the "Brown is honest," which I use to express my own belief in his being honest. That is, no variant or single substitute for "is" will change "Brown is honest" from the expression of my belief into the expression of my belief (or hope, or expectation, etc.) that you believe. In short, there seems to be no opportunity for condensation, such as is required to change "I wish you to tell me your believing-or-disbelieving the truth of Brown to be honest" into a question, e. g., "Is Brown honest?"

by my failure to believe or disbelieve, with a very similar indefinite. Indeed, if "something" be allowed the verbal power, I may say "I something Brown to be honest." It is true that the proper word would be "nothing." Yet it would hardly stretch the power of symbolism to the breaking point, were I to insist that in this case "something" should cover "nothing," just as the algebraic x includes all values, even that of zero.*

Returning to my illustration, I propose accordingly to change "your believing-or-disbelieving the truth of Brown to be honest" into the form of a judgment, really yours, but linguistically feigned to be my own, or put as indifferently yours or mine. This judgment will appear, then, as my (for your) believing-or-disbelieving, etc. To avoid confusion, I deal for a moment with only the former of the two alternatives, believing and disbelieving. Accordingly, "my (for your) believing the truth of Brown to be honest" is to be so changed, as to have the meaning expressed by "Brown is honest." Now, without puzzling over such a refinement of self-examination as contemplates belief (or its absence) in one's own believing, it is perhaps enough to put it roughly that, in the expression "my for your believing, etc.," I am merely *talking about* believing. On the other hand the expressions "Brown is honest" and "I believe Brown to be honest," each of which stands for a judgment, represent me as *experiencing* that believing which I talk about. I will accordingly make use of this experiencing, to effect the change of "my (for your) believing, etc." into the form of a judgment. That is, instead of "my (for your—or, say, my or your) believing-or-disbelieving the truth of Brown to be honest," I will substitute "I (for you) experience believing-or-disbelieving the truth of Brown to be honest."

Now this believing-or-disbelieving is not only what I (for you) experience, but also at the same time what I wish you to tell me. That is, it is a simultaneous factor of two judgments, which, by the very simultaneous presence of that factor in each one,

*In fact I might develop the indefinite judgment into "I either or neither believe or disbelieve." But this would be presumably going quite beyond what may be conceived as likely to happen in the linguistic thinking of minds at the stage of development marked by the creation of the judgment interrogative as to belief.

become a mental unit. This can be most easily shown by a diagram; accordingly,

I (for you)
experience
I wish you to tell me the believing-or-disbelieving
the truth of
Brown
to be
honest.

ITS OPERATION ON THE HEARER'S MIND.

As previously argued (See p. 428) any thought may be conceived as consisting of any one of its parts, plus the remainder; and that remainder may serve as restricter or distinguisher of that part. Applying this doctrine to what may be called the perpendicular thought, as diagramed above, and conceiving that thought as constituted of "believing-or-disbelieving" and a remainder, I regard the former constituent as restricted or distinguished by the latter. That is, the particular believing-or-disbelieving which I wish you to tell me, is separated for you from others, by its being the one experienced in connection with the truth of Brown's being honest.* Accordingly, if you succeed in thinking after me my perpendicular thought, you will know what I wish you to tell. At the same time you will know that I wish you to tell it to me, if you succeed in thinking after me what may be called the horizontal thought.

Now your success in thinking my thoughts after me is my success in expressing them. Accordingly, interrogative needs will be met, if I can change my diagram into a successful sentence—that is, if, given a judgment interrogative as to belief, I succeed in

ITS EXPRESSION BY A SENTENCE.

What is offered by the last diagram (see above)—that is a judgment interrogative as to belief—is in my opinion roughly what is meant by the interrogative sentence "Is Brown honest?"

*Any argument supporting this proposition would be an essential repetition of pp. 415–416, 426–428.

To establish this opinion, I might begin with the sentence, striving to develop the meanings of its members to such an extent, that the total of their meanings would tally with that of the diagram. It will be however simpler, and presumably more satisfactory, to proceed in the inverse direction. I assume then that, in using the question "Is Brown honest?," I mean what was meant by the diagram. Next I endeavour to show how the meaning of the diagram can be expressed by the words of the question.

In the first place, the diagram contains by far too many words. The practical need of greater brevity may be accepted as the final cause, or the "raison d'être," of the conventional interrogative sentence. For the latter, I will first prepare the way, by a series of reductions in the diagram.

In order to have the believing-or-disbelieving in convenient shape to be the object of "I wish you to tell," I contrived to introduce it into the diagram, in substantive form. But obviously the "believing" will still be there, and still be conceivable as the object of "tell," even if I incorporate it with "experience" in the total meaning expressed by "I believe;" and the like is true, if I substitute "I disbelieve" for "I experience disbelieving." Accordingly I change my diagram into

I (for you)
I wish you to tell me believe-or-disbelieve
the truth of
Brown
to be
honest

To reduce this diagram further still, I utilize the brevity of the imperative, obtaining

I (for you)
Tell me believe-or disbelieve
the truth of
Brown
to be
honest

To effect a further reduction, I need a single word which can express the meanings of two or more of the words thus far em-

ployed. Confining attention for the moment to the perpen dicular expression, I note that "Brown" and "honest" will ap pear in the conventional question "Is Brown honest?" That is the ideas expressed by these words will have, each one, its spe cial symbol: neither of them will be incorporated in the mean ing of any substitute for words employed in the diagram. Then remain then, subject to possible incorporation, the more or les composite ideas expressed by "I," "believe-or-disbelieve," "th truth of" and "to be."

Now all these four ideas together could be expressed by single word, if only, instead of the meaning expressed b "believe-or-disbelieve," I had the meaning expressed by "believe alone. For instance, in "Brown is honest" (Conf. illustratio p. 392; also p. 394) the "is" expresses all that is expressed by " believe the truth of Brown to be honest," except what is ex pressed by "Brown" and "honest." The "is" in this case ma then be defined as meaning "I," "believe," "the truth of"..... "to be"......

Let now a different "is" be conceived, with the partly ind finite meaning expressed as follows: "I," "believe-or-di believe," "the truth of"..... "to be"..... This indefini "is," which I am going to try to develop into an interrogati "is," may be distinguished by writing it with italics—accordin ly, *is*.

The use of such an *is* will effect, of course, an important ga in brevity; but it will sacrifice by just so much the power directing special attention to any particular one of the element which it expresses. It can not indicate which one of these wish you to regard as simultaneous judgment-factor. But *i* does not need to do this. It is true that, of all these elements— namely, "I," "believe-or-disbelieve," "the truth" and "to-be"— I wish you to use, as simultaneous factor, only a particular one. But that one is clearly indicated by the very nature of the case. Being what I wish you to tell me, it will surely not be what i already in my mind and quite distinct—not, that is, a definit element—not an element expressible by "I," "the truth" or "t be." It can therefore only be the element expressible b "believe-or-disbelieve."

I propose, accordingly, to substitute the indefinite *is* for th "I believe-or-disbelieve the truth of .... to be" of the preced ing diagram. As to the place in which to put this *is*, I not

that, when I reduce "I believe the truth of Brown to be honest" to "Brown is honest," the ordinary "is" elects the place of "to be." Giving for the moment the like position to the indefinite "*is*," I make the diagram

Brown
Tell me *is*
honest.

In this I intend the "*is*," as member of the perpendicular sentence, to stand for the four meanings of "I," "believe-or-disbelieve," "the truth of" and "to-be;" but in its membership of the horizontal sentence—that is, as the object of "Tell" in "Tell me"—I heed exclusively that one of the four expressed by "believe-or-disbelieve."

For this diagram I wish to substitute a presentation, of the usual linguistic type—a change which must be made with some precaution. For language, be it written or spoken, will be confined to, so to speak, a single line. I am to pass, accordingly, from presentation in two dimensions, to presentation in one dimension only. In doing so, I wish, if possible, to retain for any new expression the advantages afforded by the old. Now the particular advantage of the old was this, that each of its two sentences, in even their most highly complex form, appeared as a continuous, unbroken whole. I do not therefore wish to substitute, for instance, "Tell me Brown *is* honest;" for, in such an expression, I break the horizontal "Tell me *is*" of my diagram, by interpolating "Brown," a part of the perpendicular "Brown *is* honest." To maintain the continuity of both the horizontal and the perpendicular, as they range themselves upon a single line, I must make their simultaneous factor, at the same time, the end of one and the beginning of the other.

In doing so, I merely repeat the arrangement of ideas employed with an interrogative thought expressed by the aid of a recognizedly interrogative word, for instance, "Who?"—a thought, that is, in which the desideratum is an essential element of a mere conception (Conf. p. 411). In expressing such a thought, I framed the sentence "Tell me some one (=him [who] =who) killed Lincoln." In the sentence thus arranged, the "some one," viewed as desideratum—that is, as object of "Tell (me)"—was put in its natural position after "Tell me." At the same

time the "some one," viewed as an indefinite, was in a position eminently suitable for being defined by "killed Lincoln."

The case of the *"is"* impresses me as quite analogous—capable of the same advantageous treatment. One element of its meaning figures as the desideratum—namely, believing-or-disbelieving. As symbolizing that desideratum, the *"is"* will naturally take position immediately after "Tell me," as a direct object. That element of meaning is, moreover, also an indefinite. As symbol of that indefinite, the *"is"* will naturally not mingle with the elements which are to define it; that is, it will take position immediately before (or immediately after) the words by which it must be defined—that is, before or after "Brown" and "honest." But it cannot come after them, without losing its well nigh indispensable connection with "Tell me." Accordingly it shall come before them.

Apparently then, in changing from diagramatic to sentential presentation, all old advantages may be retained, analogy preserved, and new advantages acquired. I therefore do not hesitate to substitute the sentence

(Tell me [*is*) Brown honest].

In writing this, I use the parenthetic signs as well as brackets, to show that my sentence is really two, being the expression of two judgments; and that a part of what is meant by *"is"* should be regarded as at the same time factor of one and factor of the other judgment. This simultaneous factorship I also believe to be, at the outset, the only operative motive for the chosen verbal order. I do not indeed forget that, when my sentence shall become the question "Is Brown honest?", some will have it, that the question-form has been developed by "inversion" operating on the statement "Brown is honest." But I can not regard the interrogative order of words as reached by any puss-in-the-corner game between the verb and subject; nor can I regard the so-called inversion as, at the outset, any conscious warning of interrogative purpose. I believe that, whatsoever might, in assertion, have been the order followed by "Brown," "honest" and "is," the *"is"* would, in a question, go to the head of the sentence, irrespective of any apparent place-exchange with either of the other words. In short, I believe that it takes its place according to fundamental principles of thought-construction, adapted to the special limitations of sentential presentation.

Incidentally I note that the position of "Is," as sentence-head in "Is Brown honest?", tallies exactly with that of "Who?" in "Who killed Lincoln?" That is, the "Is" and the "Who?" which I shall claim to be, each one of them, a question-asking word, agree in being put in the initial position.

Now it is an accepted tendency of untutored minds, to place at the sentence head the word for whatever idea is momentarily of dominant interest; and as such I rank desired ideas indicated (along with other ideas) by "Who?" and "Is." Accordingly, though I for one should not incline to regard this tendency as actually accounting for the position of either "Who?" or "Is," I nevertheless perceive that this position eminently satisfies that tendency; and I conclude that such position, once elected for the reasons indicated, is approved, confirmed, conventionalized by such a tendency.

The expression "Tell me *is* Brown honest," though in actual use and for an interrogative purpose, does not rank as an "interrogative sentence." To be so ranked, it must still further be reduced in bulk. Indeed a further reduction is to be expected. Just as in "Tell me who killed Lincoln," I found that the strictly indefinite "who" was pitched upon to do the question-asking; so also in "Tell me *is* Brown honest" I expect that the *"is,"* on account of its partial indefiniteness, will be selected to perform the interrogative duty. It is almost, also, a foregone conclusion that, just as "Who?" equipped itself for this duty, by assuming the meanings of all sentence-elements except those of restrictive value, so also the indefinite *"is"* should fit itself for larger function, by corresponding augmentation of its meaning. That is, reduction is to be effected by incorporation.

Accordingly, by a supreme effort of multiple symbolization, the already heavily loaded *"is"* shall be made to bear the further burden of what is meant by "Tell me"—what is meant, that is, by "I wish you to tell me." In short, the indefinite *"is"* becomes an interrogative IS—a word which, in this augmented meaning, I find it convenient to write in capitals.

If the reasoning followed be correct, it appears that, just as in "Who killed Lincoln?" the "Who?" is regarded as the specially interrogative symbol, so also in "IS Brown honest?" the "IS may be regarded as

THE SPECIALLY QUESTION-ASKING WORD.

The duty of such a word I can not regard as done by inversion, for reasons indicated on pp. 462 and 404, or by the rise of voice at the sentence-end, for reasons indicated on p. 403.* I must regard such duty as done by what I have called the interrogative IS.

That, in the sentence "IS Brown honest?," the IS performs a duty quite analogous to that of "Who?" in "Who killed Lincoln?" —that also the difference between this IS and the *is* of "Tell me *is* Brown honest" tallies closely with the difference between the "Who?" of a question and the "(him) who" of "Tell me (him)

*The actual value and the operative method of the "rising inflection" may be suggested here as well, perhaps, as elsewhere. Suppose for a moment the information-seeking sentence of p. 462 to be formed in the inverse order of thought, and expressed as follows: (Honest Brown [*is*) me tell]—or, more simply, "Brown *is* honest—tell me." If now the imperative phrase ("tell me") be dropped, it will be felt that the speaker has stopped before his sentence is completed. The same impression was no doubt at first produced, when "Tell me *is* Brown honest?" was reduced to "IS Brown honest?" Presumably some time elapsed before the originators of the interrogative sentence came to feel that what, at first, had been expressed by "Tell me," was incorporated into the meaning of "IS Brōwn honest?" Meantime the latter expression was felt to be elliptical, or incomplete.

Now the completion of a sentence is commonly attended by a fall in vocal pitch. Neglecting other causes, I observe that, when a muscular activity is near its end, it is commonly somewhat lessened. In speaking, when the linguistic purpose of the moment nears fulfillment, the talking muscles are relaxed, including those which regulate the tension of the vocal chords. As the latter muscles abate their effort, the vocal chords themselves are slackened, and the vocal pitch descends. Presumably this unintended fall of pitch, when once familiarly associated with completion of the sentence, was deliberately utilized to indicate sentential close, and exaggerated for the sake of easy recognition.

On the other hand, until the sentence end is reached, the average vocal pitch is naturally maintained. Pitch-maintenance would therefore properly become the sign, that the speaker has not finished what he has to say—that, even though he ceases speaking, what he has said is incomplete. Moreover, just as fall of pitch, the sign of completeness, was exaggerated downward, so also maintenance of pitch, the antagonistic sign of incompleteness, would naturally suffer, so to speak, exag-

who killed Lincoln'"—will perhaps appear more plausibly, if I may put the operation of the IS in the light afforded by another means of symbolizing, purely theoretical. Let it then be seen how interrogative purpose might be accomplished by a quite imaginary symbol, built on the lines of an interrogative pronoun.

To break the way for such a symbol, I note that words included by Grammar in the pronominal word-class have, with little formal variation, quite a range as parts of speech, or say in sentential function, though they do not, so far as I have noted, operate as verbs. For instance, the demonstrative may act as substantive or adjective or adverb (e. g. "there," "thus" etc.). It does not, however, appear as verb, though obviously it has the

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geration upward—that is, sentential incompleteness would be marked by rising inflection.

When once, however, the omitted "Tell me" is understood to be a part of what the interrogative sentence means, the rising inflection would seem to be no longer needed. If, indeed, the interrogative "IS" were different in form from the "is" of ordinary assertion, I should say that rising inflection would be entirely superfluous. But, as such is not the case, the rising inflection, and also the interrogative order of words ("inversion") continue an auxiliary service in establishing the interrogative IS as such, in distinction from the commoner assertive "is."

Both expedients, however, are frequently used for other purposes. (See pp. 403–404.) Both are, in American English, renounced with questions which employ recognizedly interrogative words (e. g., "Who killed Lincoln?") Indeed, the rising inflection is sometimes neglected even when no recognizedly interrogative word is present. To illustrate, "The question before us is the following: Is Brown honest?" So also sometimes in a contrasted sentence-pair, consisting of a statement and a question, the statement is uttered with the rising inflection—the question with the falling: e. g., "*Jones* is honest. Is *Brown* honest?" "Brown is *agreeable*. Is he also *honest?*" Also the inversion is sometimes neglected, as in the so-called statement with rising inflection: e. g., "Brown is honest?" I do not, however, think of a case in which the question (without especially recognized interrogative word) omits both inversion and rising inflection. Nor should I expect the omission of both these interrogative indications, until some substitute shall be provided, to distinguish the interrogative IS from the "is" of ordinary assertion. Meantime these two indications, either alone or both combined, appear to me to do for the IS precisely what the acute accent does for the τίς of Greek.

latent power to do so, as in "Booth thissed or thatted Lincoln." The indefinite has no less range, and no greater ambition, failing to develop the plainly possible "Booth somethinged Lincoln." The relative has equal freedom, but also does not assume the verbal function, though it might be forced to do so, as in "This is the carpenter who mends the stables, and also whiches (=mends) the fences of the neighborhood." With the even subtler interrogative, a verbal usage would be even less expected. Yet the interrogative pronoun itself may be compelled to act as verb, for instance in "Booth whatted Lincoln?".

The question asked, however, by the words of the last illustration, is not by any means the sort of question examined in this chapter. What these words do ask for—that is, the indefinite desideratum, or say the desired indefinite—is the relation between a subject and an object, or say the action in which a subject and an object both are implicated. The desideratum then is an element of essential thought, as also is the case with "Who killed Lincoln?" and "Whom killed Booth?". On the other hand, the interrogative sentence "IS Brown honest?" operates in a deeper mental stratum. Its desired indefinite is the secondary process of believing or disbelieving, which bears upon the truth of a thought complete in every essential—the thought expressible by "Brown to be honest."

Now this indefinite, even when merely indefinite and not also desired, is much more difficult to symbolize, than the indefinite action or relation above considered. "Booth somethinged Lincoln" seemed the merest and altogether natural extension of existing language means and methods. But, in saying "I something (=believe-or-disbelieve) Booth to have killed Lincoln," I seem to be going quite beyond all precedent. Yet, in the invention of my proposed imaginary symbol, a start with essentially such an indefinite, I seem obliged to make. Indeed, in all development of interrogative words, I am personally unable to conceive a start from anything but the unknown; and this can be mentally pictured only as indefinite. In order then to coin an interrogative word, which shall take the place of IS in "IS Brown honest?"—a word which plainly must, like "IS," be operative as a verb—I must have, to start with, a verb which, also like the IS, shall be indefinite, and indefinite as to belief or disbelief. Accordingly I begin with an *is* which (as described on p. 460) I pose as meaning, not simply "I believe to be. . . . .,"

but rather "I believe-or-disbelieve to be. . . ."—that is, "I *something* to be. . . ." If now I can by usual means transform this indefinite verb into an interrogative verb, my immediate purpose will be accomplished.

Now languages very often have, among their stock of elements for word-construction, one which makes an interrogative out of the indefinite word to which it is applied. Thus, absolutely slighting historical origin, I may say that, when the meaning of the Latin "id" (= it or that) is not sufficiently definite, becoming that of which I wish you to give me information, by the simple addition of "qu" I turn it into "quid," which I should define as meaning "I wish you to tell me that (which)." So, too, in English, so soon as an idea of place, suggested by "here," is too indefinite for toleration, becoming that of which I wish you to give me information, by the simple addition of "wh" I turn it into "where?," which I might define as meaning "I wish you to tell me the place in which." That is, by means of a prefix, I change an indefinite into an interrogative.

Given now "Brown is honest," and extending the meaning of the "is" to cover for the moment not merely belief, but indefinite belief-or-disbelief (in the truth of ..... to be .....), by the addition of the "wh" I could change this indefinite "*is*" into "Whis," a word which should by analogy be not only indefinite, but also interrogative, meaning "I wish you to tell me your belief-or-disbelief (in the truth of .... to be ....). Accordingly I develop "Whis Brown honest?"—an expression which I offer, not because I greatly hope that it may prove a successful neologism, but because it formally exhibits the IS of the question "IS Brown honest?" in that analogy with other question words, to which it seems to me to have a rational claim.

Its meaning.

Retracing now the steps of argument—and in the inverse order—starting with the interrogative sentence, e. g. "IS Brown honest?," I have found its meaning to be

"I wish you to tell me *is* Brown honest" (*is* being indefinite) or, in a diagramatic exhibition,

				Brown
I wish you to	tell	me	*is*	
				honest

or more fully,

I (standing for you)
I wish you to tell me believe-or-disbelieve
the truth of
Brown
to be
honest.

Now the "Brown" and "honest" of the last diagram tally exactly with the "Brown" and "honest" of the interrogative sentence "IS Brown honest?" So far then as cancellation of equivalent terms can be trusted to reveal equivalence of remaining terms, it appears that the remaining IS of "IS Brown honest?" is equivalent to what remains of the diagram—namely, "I wish you to tell me you believe etc.," or more smoothly, "Tell me your believing-or-disbelieving the truth of .... to be ...." (Conf. note, p. 436).

As the relation expressed by "to be" is only one of many relations with which the interrogative sentence may deal (Conf. "Equals A B?," "Killed Booth Lincoln?" etc.), therefore a general definition of the specially question-asking word of the affirmative interrogation now considered, would take the form "I wish you to tell me your believing-or-disbelieving the truth of ..... to —— ....." On the other hand, as the negative interrogation "Is n't Brown honest ?" asks for belief-or-disbelief in untruth, that untruth might be expected to take the place of truth in definition; but as that untruth is specially expressed by "not," therefore a proper definition of the negative interrogation's question-asking word will not contain that element of untruth, which would correspond to the truth contained in the above definition of the question-asking word of affirmative interrogation.

Passing by a number of interesting expressions even more densely packed with meaning,* I close examination of the specially question-asking word, with a comment on

Its rank.

Like the interrogative "Who?" the closely analogous interrogative "IS" compels me to regard as idle any effort to rank it as a "part of speech." It is obviously not a *part* of speech,

*E. G., in answer to the statement "Brown is n't honest," the following: "Nicht?", "Vraiment?", "So?", "Isn't he?" etc.

but again a speech *complete*—and more. It is, on the one hand, the assertion of my desire that you tell me something. That is, in meaning, it is not a word, but a sentence. On the other hand, in form, it is not a sentence, but a word. It is, with many like expressions, most conveniently known as a one-word sentence.

From the main body of its fellows I differentiate it as follows: it operates not merely as a single sentence, but also as part of a second sentence. Given two judgments with a common factor, it symbolizes all of one and a considerable part of the other—is, roughly estimated, a sesqui-sentence.

From its nearest of kin, for instance "Who?," it is distinguishable by the nature of the special void which it aims to fill. Likening the act of judgment to the objective act of weighing, I note that the question of the "Who?" type seeks for an object to put in the balance. The question of the "IS" type seeks for a reading on the dial. They are respectively question of cause and question of effect—question of datum and question of conclusion.

Those who think of words as always sentence-factors—as "parts," that is, "of speech"—have opportunity to add a species to the genus known as verb. For, granting that the question "IS Brown honest?" means "I [1]*wish* you [2]*to tell* me your [3]*believing-or-disbelieving* Brown [4]*to be* honest"—and that all the meaning of the paraphrase (that of "Brown" and "honest" excepted) is expressed by the IS of the question—it is plain that, in many conjugational systems, the IS might four times over claim the verbal rank; and, as it also does what may be specially known as the question-asking, the IS might claim a special rank as an interrogative verb.

Those, again, who hesitate to form new species, may elect to rank the verb of the interrogative sentence as a mere variety, or say a mode. Grammarians rank one form of the unassertive verb as the infinitive mode. The verb which merely asserts, they call the indicative mode. The verb which asserts desire, they call the imperative mode. The verb which asserts desire to be informed, they may consistly call, as some indeed have called it, the interrogative mode.

This brings me back to my initial propositions. Neglecting classification of expressional elements into modes and parts of

speech, and centering attention on mental totals expressed, I find the simplest form of thought considered, to be the mere conception of two terms and their relation, commonly further posed as true, or else untrue, and expressed by a merely suggestive (that is, an unassertive) phrase. The addition of personal belief produces the ordinary judgment, expressed by the merely assertive sentence. The intercalation of desire produces the imperative judgment, expressed by a pregnantly assertive sentence, or command. The further intercalation, expanding desire into desire to be told an indefinite judgment element, produces an interrogative judgment, commonly expressed, according to the nature of the indefinite element, by one or the other of the examined forms of the question—both of which, however, rank as merely still more pregnantly assertive sentences—or, say, as pregnantly imperative.*

In closing, I wish to express the keenest appreciation, that my own line of groping amid the obscurities offered by interrogation, may be very ill adapted to another mind whose light is stronger. On such a mind I venture only to urge attention to the following probabilities: that every question (asked for information) presupposes that an element is more or less entirely missing from what might have been a prior judgment; that the desideratum of a question is, in the asker's mind, an unknown or an ill known substitute for that missing element—that is, an indefinite; that the question must provide the hearer with a clue to this indefinite, and cannot do so, as it would appear, except by naming its definite fellow judgment-members; that every question naturally also exhibits the desire to be told the indefinite substitute; that this desire is presented as not merely thought of, but also actually felt; in short, it is circumstantially probable, that the question should in some way assert desire to be told the indefinite element of a thought exhibited in the form of a judgment.

Madison, Wis., July, 1903.

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* I should perhaps have added elsewhere, that an imperative value of the question is rather strongly hinted by the tone in which it is sometimes uttered. Thus, to the disturber of my peace, I shout "Who's there?" in just the tones that I should use in saying "Go away!"

A WISCONSIN GROUP OF GERMAN POETS.

WITH A BIBLIOGRAPHY.

HENRY E. LEGLER.

In the making of the social and political life of the United States as found at this day, two notable tides of immigration from Europe have had a part greater than all others. Spanish and French influences were as waves upon the sand; the ideas and customs of the Puritan and Pilgrim forefathers in the early years of the Seventeenth century, and those of the German immigrants two centuries later have been graven deep, and in the modifications due to constant contact may be traced the growth of the institutional conditions existing at the dawn of this new century.

New England's radiating influences have been employed as a topic by many able historians, but the importance of German influence as permanently affecting American life has up to this time received but scant mention. That importance must be ascribed primarily to the remarkable contingent termed the Forty-Eighters. Unlike the simple pastoral people who followed Johannes Heckewelder, David Zeisberger, George Heinrich Laskiel, Franz Daniel Pastorius and other religious shepherds of the Seventeenth century to a New Canaan, the Forty-Eighters of the Nineteenth century were men of rank and education.[1] Among them were many college professors, journalists, men of high literary attainments, university students of noble families, who sacrificed home, fortune, position, brilliant prospects—all

[1] The Germans in Wisconsin Politics, by Ernest Bruncken, *Parkman Club Publications, No. 9*, gives an excellent brief sketch of the aims, purposes and characteristics of the Forty-Eighters, p. 225–227.

the material advantages that men ordinarily cherish, in an effort to bring to their distracted countrymen liberty of thought and action. A hundred thousand of these political refugees and their sympathizers came to America in that stirring period of storm and stress when *Die Wacht am Rhein* became the expression of nationalist spirit. They were young; they were fired with enthusiasm, with energy; they possessed skill of pen and of speech. In all the leading cities of the United States east of the Mississippi they exerted a potential influence in the educational movements of the time, and naturally their activity soon extended to the significant political movements that foreshadowed the great struggle of the Sixties.

For reasons which it is necessary to mention but briefly here, Wisconsin attracted a large element of the political exiles.[2] In 1844 Moritz Schoeffler established a German printing office in Milwaukee, and his press turned out thousands of pamphlets descriptive of Wisconsin's attractiveness. These were distributed in the various provinces of Germany and guided thousands of immigrants hither.[3] The state seconded these efforts a little later on by establishing a bureau of immigration, whose representatives met the newcomers in New York City and encouraged them to proceed to Wisconsin. In Milwaukee, German immigrants arrived by the hundreds every week. German newspapers multiplied; German schools were established; German art, German song, German literature and German social life received an impetus that caused Milwaukee to become known as the "German Athens of America." The Banner und Volksfreund established a department which it called "Wisconsin's Deutsche Dichterhalle" (Wisconsin's German Temple of Poesy), and the ready pens of the Forty-Eighters contributed thereto a mass of literature of great originality, richness and beauty.[4] About the same

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[2] Carl Schurz became the most noted among them. He was a candidate for lieutenant governor on the Republican ticket in Wisconsin in 1856. In 1859 he tried unsuccessfully to secure the Republican nomination for governor. See letters of Carl Schurz to Congressman John F. Potter printed in The *Milwaukee Sentinel* April 1, 1900 (edited by Henry E. Legler). See also A. M. Thomson's *Political History of Wisconsin.*

[3] Letter of Moritz Schoeffler to the Wisconsin Editorial Association at Oshkosh, 1869. *Proceedings*, p. 19.

[4] Wisconsin's *Deutsch-Amerikaner*, Vol. 2. p. 5.

time Bernhard Domschke issued the initial numbers of the *Corsar,* and Christian Esselen launched his high-class periodical called *Atlantis.* The most intellectual and gifted German-Americans were spurred to renewed literary endeavor, and naturally an interesting literary group was formed in Wisconsin. Some of its members have found a permanent niche in the German hall of letters. A curious literary war was waged about this time in the United States, with the storm center in Milwaukee, known as the war of the Grays and the Greens.[5] The former were represented by the old conservative Germans, leaders of the earlier immigration, whose ideas were rooted in religion. The Greens were the Forty-Eighters, chiefly idealists and extreme radicals whose bitter sarcasm and vitriolic humor disturbed, but did not vanquish, the less ready-tongued Grays. Old residents of Milwaukee will recall a favorite tavern on Market street where the Grays and Greens were wont to forgather to pursue with tongue the arguments begun with pen. The Grays did not lack earnestness and faith, but what they wrote was not literature. The Greens clothed their effusions in form to please the ear as well as to appeal to reason.

It was indeed a notable group of literary writers. Some years ago, under the auspices of the leading Chicago German-Americans, there was compiled a critical anthology of German-American literature.[6] In the period devoted to the Forty-Eighters, thirty-one poets have been deemed worthy of representation. Seven of them were residents of Wisconsin, including Madame Mathilde Anneke, Konrad Krez, Edmund Maerklin, Ernst Anton Zuendt, Augustus Steinlein, Rudolph Puchner and Henricus vom See (Wilhelm Dilg). The heart and soul of this notable group, which included many other members of minor poetic talent, was Madame Anneke. This gifted woman, whose energetic nature and rare sympathies were freely at the disposal of the weary and heavy-laden, exerted an influence upon those who came within her circle that was truly remarkable. Sorrow and disappointment pursued her from childhood, but she faced every succeeding misfortune with cheerful courage, inspiring her asso-

[5] Wilhelm Otto Soubron in The *Sunday Sentinel,* May 10, 1903.

[6] Zimmermann's *Beiträge zur Geschichte der Deutsch-Amerikanischen Literatur.* Chicago, 1902.

ciates to like spirit. But in her verses she poured out the feelings of her heart. They are

> Short swallow flights of song
> That dip their wings in tears.

An unhappy early marriage and consequent legal struggle to obtain possession of her child led her to become a warm advocate of equal legal rights for women. She established in Germany what was doubtless the pioneer woman's rights journal—which the government promptly suppressed. Her second husband, Fritz Anneke, was a Prussian officer whose sympathies became enlisted in the cause of the revolutionists of '48. When Anneke was imprisoned at Cologne awaiting trial on the charge of treason, Madame Anneke sold furniture and carpets and replaced them with a printing press, editing a revolutionary newspaper till forced to fly for safety. In the meantime her husband had been liberated, and she joined him in the field. She accepted a place on his staff, of which Carl Schurz was also a member. Madame Anneke served till the end of the struggle, saw many battlefields and was in the thickest of the fray, doing a soldier's duty and sharing all the hardships of her soldier husband. They were forced to flee for their lives, finding haven first in France, then in Switzerland. In 1849 they came to America. Madame Anneke lectured to large audiences in Boston, New York and Philadelphia. In the '50's she began the publication of the *Frauenzeitung*. The latter period of her life was devoted to educational work.[7]

Interesting as are the careers of the other members of Madame Anneke's circle, the limits of this paper will not permit extended mention. Edmund Maerklin was a member of Franz Sigel's staff in the Revolution of '48. He was a personal friend of such well-known German literary men as Uhland, Gustav Schwab, Justinus Kerner, Nicolas Müller and Herwegh. He was the author of many keen satires. His celebrated poem "Der Deutsche Cavallerist," written when Vicksburg capitulated, is said to have been printed at the time in every German newspaper published in North America.[8]

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[7] A sketch of Madame Anneke's interesting career was printed in The *Milwaukee Sentinel* Nov. 26, 1884.

[8] Carl Anneke contributed a long and excellent sketch of Maerklin to *Im Strome der Zeit*, Milwaukee, 1886, p. 4–8.

Konrad Krez was a young exile who left his fatherland under sentence of death at the age of 20, but whose heartstrings remained rooted in German soil to the day of his death—and he lived to nearly the allotted six score years and ten. His exquisite lyric "An mein Vaterland" has been reprinted in every German anthology that has appeared since the day the poem was first published. There is not in the German language a poem that conveys so poignantly the feeling of *Heimweh*. The chaste and simple words stir one powerfully with the pathos of the exile's cherished love for a fatherland which he can never see again. The verses have been set to music by two composers. One version, by Th. Rudolph Reese, was published in Milwaukee in 1898. The other composition, by Richard Ferber of Eau Claire, was awarded first prize at one of the great sängerfests. At least two translations of the poem into English have appeared. I venture to give one by Wilhelm Otto Soubron. Excellent as this translation is, it fails to express fully the intense fervor and pathetic cadence conveyed by the original tongue.

TO MY FATHERLAND.

Mine was no tree within thy forests old,
Mine not a sheaf of all thy grain fields gold,
And without pity thou didst bid me go,
  The unprotected, to a foreign strand—
Because for thee my soul, and not for self did glow—
  And yet I love thee, O my Fatherland!

Beats there a heart, that of the youthful dream,
Its first sweet love, does not retain a gleam?
Ah! holier was the flame within my breast
  Than lovers e'er with ardor fanned;
Ne'er bride, nor bridegroom e'er so blest,
  Held faith like mine, dear Fatherland!

No "manna" heaven poured on thee, I know,
Yet many were the gifts it did bestow:
I saw the wonders of a Southern clime
  Since last I on thy soil did stand,
Yet fairer seemed to me than palm and lime,
  The apple blossom of my Fatherland!

Land of my fathers! though no longer mine,
If any soil is sacred it is thine!
Thy image, always bright, is in my mind,
And if no tie were wrought by living hand,
My cherished dead would me to thee still bind—
Thy holy graves—O thou, my Fatherland!

O, if thy children all, who stayed at home,
Did love thee like the ones thou badest roam,
A Union soon, an empire would have birth,
And thou wouldst see thy children hand in hand
Make thee the mightiest land on earth,
As thou'rt the best, my Fatherland!

The story is told that the German emperor chanced upon Krez's poem in a German publication, and was so affected that he caused the restrictions applicable to the return of the Forty-Eighters to be greatly modified. Whether well-founded or not, the story might well be true. All of these Forty-Eighters poured out their aching hearts in verse, and naturally what they wrote rang true. Any of these outbursts stirs the pulses of him who reads:

"Farewell to Germany," by Puchner.

"At Parting," by Maerklin.

"To My Fatherland," by Krez.

Of the few writers who antedated the Forty-Eighters, mention may be limited to Carl de Haas of Fond du Lac, and Alexander Conze of Milwaukee. Conze gave promise of a great poetic gift, but he found a soldier's grave in Mexico when but 28 years of age.[9] Desire to die on the battlefield, due to personal disappointments, is said to have prompted his enlistment in the Mexican War.

The names that most readily occur of the recent school of German poets are those of Frank Siller, Otto William Soubron and Julius Gugler. Mention must not be omitted, in even a brief review of Wisconsin German poets, of the excellent translations which American poetry has been given at their hands—chiefly by Siller and Soubron. Longfellow's poems have been

[9] His well-known "Oregon Lied" is reproduced in *Milwaukee*, by R. A. Koss, Milwaukee, 1871, p. 194. Several others of his poems are given, p. 224-228.

favorites in this particular. William Dilg translated "Hiawatha," and Frank Siller "Evangeline." In the latter, Longfellow recognized the best German version of his Acadian poem. It preserves not only the spirit of the original, but renders in like meter practically a literal translation of the story, with all its idioms and characteristics. Siller translated from many languages. His paraphrases of thirteen quatrains from Omar Khayyam (printed in 1889) were the first attempt of the kind in America.[10] Among other translations deserving mention are the following:

"Paradise and Peri" (Moore), by Dr. Max Doerfling.

"Abou Ben Ahdem" (Leigh Hunt), by Augustus Steinlein.

"America" (Smith's patriotic anthem), by Carl Doerflinger.

"Excelsior" (Longfellow), by Franz Siller; also "The Angelus at Dolores" (Bret Harte); "Laugh and the World Laughs with You" (Ella Wheeler); "To Maria Clemm" (Poe).

"The Arrow and the Song" (Longfellow), by Herman Ruhland.

BIBLIOGRAPHY.

ANNEKE, MATHILDA FRANCISKA.

B. April 3, 1817, in Blankenstein. D. Nov. 25, 1884. She had fine literary talent, her youthful contributions in prose and verse attracting the attention of the poet Ferdinand Freiligrath. Many of her poems were translated into English by Mrs. Mary H. C. Booth, wife of Sherman Booth (Wayside Blossoms Among Flowers from German Gardens, Milwaukee, 1864). A tender friendship existed between these two women. Mrs. Anneke's eventful career is narrated in an article printed by Henry E. Legler in The Milwaukee Sentinel of Nov. 26, 1884.

—— Oithono, oder die Tempelweihe. Milwaukee, 1844.

A poem in dramatic form. The drama was performed in Milwaukee in 1882.

BIELFELD, HENRY A.

B. in Bremen, 1818. D. Nov. 16, 1882. Usually classed as one of the minor poets of the '48 group, but not correctly so. R. in Milwaukee, where he held many positions of trust.

[10] An account of Siller's literary work (by Henry E. Legler) was printed in The *Milwaukee Record*, March 4, 1893.

BIELFELD, HENRY A.

Gedichte. Milwaukee: Freidenker Pub. Co., 1889. 196 p.

Many of the verses are local in character.

[DILG, WILLIAM] "Henricus vom See."

B. in Bingen on the Rhein in 1837. Followed his father into exile in 1849. Died in 1903 in Wiesbaden, Germany. His translation into German of Longfellow's "Hiawatha" has been much praised.

—— Gedichte. Milwaukee: J. B. Hoeger & Son, 1866. 238 p.

Eleven of the poems pertain to Indian legends, the titles (translated) being as follows: The White Canoe. The Last of His Race. Devil's Lake. Return of Spring. Schenanska. Minnehaha. Winona. Marieton Rock. Unktahee. Meuni-boschon's River.

DOERFLING, MAX.

Dr. Doerfling is a journalist. For a number of years he was an editorial writer on the Milwaukee Herold. Now r. in New York.

—— Paradies und Peri. Translated into German from the English of Thomas Moore. New York, 1887. 20 p.

DOERFLINGER, CARL.

R. in Milwaukee, where he has filled many positions of trust and honor. As an editor and publisher he gave literary aspirants much encouragement, and many books of poetry came from his press when financial loss was almost a certainty. He has contributed much to stimulate literature, art and education in Milwaukee.

—— Onkel Karl. Milwaukee, 1881.

A juvenile publication, as also the title which follows. Mr. Doerflinger contributed numerous poems to each.

—— Herzblättchen's Spielwinkel. Milwaukee: Doerflinger Book and Pub. Co., 1881. Ills. 63 p.

—— America. Aus dem Amerikanischen. Milwaukee, 1897. 8 p.

Translation of the national anthem, sung at the reunion of the Twenty-sixth Wisconsin Regiment, July 10, 1897.

ENDE, HENRICH VON.

Von Ende was a writer of romance, as well as verse. A few years prior to his death he removed to Cincinnati. His widow, Amalia von Ende, is also a well-known writer. Prior to her marriage to von Ende, Amalia Kemper was a well-known Milwaukee educator. For some years past she has made New York her home. She is a frequent contributor in prose and verse to the leading German magazines.

—— Mississippi und Rhein, Centennial-Phantasie. Milwaukee: Carl Doerflinger, publisher, 1876. 20 p.

GIEGOLD, GEORG.

R. of Marinette. Formerly a woodsman, his muse is dedicated to the spirit of the trackless forests. "Tannenreis und Flatterrosen" is his best effort.

—— Aus dem Urwald. Kenosha, Wis., 1898. Portrait and ills. 121 p.

GUDEN, SOPHIE C. [Mrs.]

R. in Oshkosh. Active in literary movements, and for a time identified with the publication of the Wisconsin Literary Independent, a monthly magazine.

—— Festival Days. Stuttgart, 1891.

Georg Ebers praised this book warmly.

GUGLER, JULIUS.

R. in Milwaukee. Author of an operetta and a drama, the latter entitled "For Mayor, Godfrey Buehler."

—— Der Stern des Westens: Episches Gedicht. Published by the author. Milwaukee, 1900. 75 p.

KREZ, KONRAD.

B. in Landau, Rheinpfalz, April 27, 1828. D. in Milwaukee. From 1850 till 1888 r. in Sheboygan. Next to Madame Anneke, Krez became the best-known German poet of Wisconsin, though Märklin's poetry as a whole ranks higher. Two poems established the fame of Krez—"To My Fatherland" and "Renunciation and Solace."

—— Aus Wiskonsin. New York: F. Steiger, 1875. v+139 p.

—— —— Second edition. Geo. Brumder, Milwaukee, 1895. 192 p.

Contains additional poems.

—— Dornen und Rosen von den Vogesen. Landau, 1846.

—— Gesangbuch. Strassburg, 1848.

The two last titles are given on the authority of Zimmermann's *Deutsch in America*. I have not seen copies of the books.

[LOCHEMES, MICHAEL JOSEPH.] "Meik Fuchs."

In addition to contributions to several collections of poems, Prof. Lochemes (r. in Milwaukee) has published poems and sketches in German and Pennsylvania-German in European and American magazines. He is especially happy in his dialect sketches.

—— Dreiguds un Noschens, vun Meik Fuchs. Milwaukee: M. H. Wiltzius & Co., 1898. 170 p.

MAERKLIN, EDMUND.

B. in Calw, Wurtemberg, Jan. 22, 1816. His poems, contributed to the leading periodicals of Germany, led to a warm friendship

with such men as Ludwig Uhland and G. Herwegh. He took an active part in the revolutionary movement in Baden, and sought an asylum in Switzerland, and later in America. In Wisconsin he became a leading journalist and with Carl Schurz led the movement which attached many of the leading Germans to the Republican party. In his poetry, Märklin's lyric note is strong and vibrant.

—— Familien-Bilder. Ein poetischer Blumenstrauss für die deutsch-amerikanischen Frauen gebunden von Edmund Märklin. Milwaukee: Carl Doerflinger, 1877. 30 p.

—— In Sattel und Meeresgrund. Schilderungen aus dem amerikanischen Bürgerkrieg, von 1860–1865. Milwaukee: Doerflinger Book & Publishing Co., 1880. 15 p.

Separate publication of Märklin's famous poem, "Der deutsche Cavallerist."

—— Im Strome der Zeit. Milwaukee, 1885. 224 p.

Selections of his best poems published as a memorial volume by Milwaukee friends, with a sketch of the author's eventful career by his comrade-in-arms, the gallant C. Anneke.

NIES, KONRAD.

B. in Rheinhessen, 1862. Identified with the German theater in Milwaukee for a time. At present r. in New York. Has contributed frequently to Puck, Frank Leslie's, Rundschau and numerous magazines. Established the monthly magazine *Deutsch-Amerikanische Dichtung.*

—— Funken. Gedichte von Konrad Nies. Grossenhain u. Leipzig: Baumert u. Konge. n. d. 186 p.

PUCHNER, RUDOLPH.

R. in New Holstein. Puchner is the last surviving member of the '48 group of poets. B. in Suabia, 1829.

—— Klänge aus dem Westen. Milwaukee: Carl Doerflinger, 1879. 132 p.

—— Aglaja. Milwaukee: Freidenker Pub. Co., 1887. 71 p.

PULS, [MRS.] MARIE.

R. of Milwaukee, wife of Dr. A. J. Puls. The book is dedicated to her daughter, and was issued for private distribution. There are sixty poems, chiefly of tender sentiment and love of nature.

—— Gedichte. Milwaukee, 1903. 79 p.

RUHLAND, HERMAN. ("Arminius.")

B. in Hanover, 1833. Came to Milwaukee in 1863. Later became a teacher in Illinois and Indiana.

— Aehrenlese. Gedichte. Milwaukee, 1878. 274 p.
— Gedenke Mein. Gedichte für Schule und Haus. Chicago, 1883.
— Deutsch-Amerikanische Feldblumen. Chicago, 1892.

SILLER, FRANK.

B. of German parents in St. Petersburg. Siller came to Milwaukee in 1850. His early life was one of hard struggle. In 1854 he went to Nebraska with a party of hot-headed enthusiasts to prevent that territory from becoming slave territory. The party disbanded and he lived a year among the Indians. In 1863 he became a grain broker, and at one time was regarded one of the leading grain operators in the country. He has written both English and German verse, and has rendered translations from many languages. His most enduring work is a translation into German of Longfellow's "Evangeline."

— Lieder und Sprüche aus dem Volke für das Volk. München: J. A. Finsterlin, 1887. 128 p.

Contains five Indian legends. Also numerous translations of leading American poets.

— The Song of Manitoba and other Poems. Milwaukee: T. S. Gray Co., 1888. 86 p.

In addition to translations from the German of Heine, Freiligrath, Zuendt, Bodenstedt, Bürger and others, there are translations from the Spanish, Panhellenic and Persian.

— Evangeline. Translated from the English of Henry W. Longfellow. Milwaukee: Doerflinger & Co. Leipzig: Ernst & Keil, 1879. 92 p.

Mr. Siller knew of no other translations of this poem into German until informed of their existence by Mr. Longfellow, who gave his preference for the Siller version.

— Ein Blick in dem Amerikanischen Dichterwald. Sonder Abdruck aus dem Magazin für die Litteratur des In und Auslandes. Dresden, n. d. 28 p.

Includes translations of the following poems: Bryant, "Spring"; Longfellow, "Excelsior"; Poe, "To Maria Clemm"; Stoddard, "Love"; Holmes, "The Sculptor"; Bret Harte, "The Angelus of Dolores"; Ella Wheeler, "Laugh and the World Laughs With You."

SOUBRON, WILHELM OTTO.

R. in Milwaukee. B. in Bremen in 1846. Has made literature his profession for many years. His education was acquired through his own unaided efforts, his younger days having been spent as a confectioner and later as a cigarmaker. His evenings were devoted to literary effort and study. His play "Asa Groot" has been translated into Danish. Soubron is a skilled translator.

—— Souvenir. Milwaukee, 1878. 253 p.

English title: Poems, by William Otto Soubron. Divided into five parts: 1. Lieder (German). 2. Poems (English). 3. Indiana–Keahsa. 4. Songs. 5. Vermischte Gedichte. The sub-title of Keahsa is "Phantasien am Lake Michigan."

STEINLEIN, AUGUSTUS.

B. in Trier, 1825. D. at La Crosse, where he had resided since 1856. He was a printer by trade, but drifted into journalism. For many years served as justice of the peace in La Crosse.

—— Bunte Blüthen. Port. La Crosse: John Ulrich, 1884. 198 p.

—— —— Second edition. Winona, Minn.: Jos. Leicht, 1892. 160 p.

THORMAEHLEN, ANTON ["Fridolin vom Wald."]

B. in Oldenburg, 1829. Came to Milwaukee in 1856, and lived here to the time of his death.

—— Lenzblüthen und Herbstblätter. Milwaukee, 1890. Port. 240 p.

VOIGT, ANNA [Mrs.].

R. of Plymouth.

—— Vergissmeinnicht. Ein Strauss Geistlicher Gedankenblüthen. Chicago: North American Pub. Co., 1896. Port. 348 p.

Chiefly poems of religious sentiment.

WALLICH, ADOLPH.

R. in Manitowoc. Formerly editor of the Wisconsin Demokrat.

—— Alpha. Milwaukee, 1872.

WITTMANN, ANNA CHRISTINE [Mrs.].

R. of Manitowoc.

—— Phantasien in der Dämmerstunde. Manitowoc: A. Piening, 1879.

ZUENDT, ERNST A.

B. in Suabia, 1819. He was the son of an Austrian count, but sacrificed title and ancestral estates to his convictions. He was thirty-two when he came to America. Founded the Green Bay Post, but his venture was not financially successful. He became "a dweller in Bohemia," eking out a precarious living in dramatic and journalistic work. D. in 1900. Zuendt possessed poetic talent. "At Lincoln's Grave" is a noble poem.

—— Lyrische und Dramatische Dichtungen. St. Louis: F. B. Meissner, 1871.

"The Song of the German–American" is given in both English and German.

—— Ebbe und Fluth: Gesammelte lyrische Dichtungen und Jugurtha, Trauerspiel in fünf akten. Milwaukee: Freidenker Pub. Co., 1894 Port. 563 p.

A sumptuous volume. In the final part of the book is given a bibliography of the numerous dramas written by Zuendt from 1843 to 1880.

—— [Anonymous] Ein Leben in Liedern, Gedichte eines Heimathlosen. Milwaukee: Freidenker Pub. Co., 1886. 184 p.

ANTHOLOGIES.

Heimathgrüsse aus Amerika. New York, 1870. 59 p.

Selections from the poems of Konrad Krez and E. A. Zündt.

Dornrosen. Erstlingsblüthen deutscher Lyrik in America. New York, 1871, 160 p.

Selections from the poems of Mathilde Franziska Anneke, Rudolph Puchner, Anton Thormaehlen and E. A. Zündt.

Deutsch in Amerika. Beiträge zur Geschichte der Deutsch-Amerikanischer Literatur. 1. Episch-lyrische Poesie. Chicago, 1892. 265 p.

Selections from the poems of Carl de Haas, Heinrich A. Bielfeld, Mathilde Franziska Anneke, Konrad Krez, Edmund Märklin, Henricus vom See [Wm. Dilg], Augustus Steinlein, Rudolph Puchner, Ernst A. Zündt, Anton Thormaehlen, Franz Siller, Otto Soubron, Julius Gugler, Henrich Ende, Adolf Wallich, Emil A. Knotser, Herman Ruhland, Konrad Nies, Bella Fiebing.

Wisconsin's Deutsch-Amerikaner, by Wilhelm Hense-Jensen and Ernest Bruncken. Milwaukee, 1902. 2 vols. 389 and 306 p.

Chapters I. and II. of Vol. 2 contain selections from the poems of Augustus Steinlein, Adolph Wallich, Rudolph Puchner, Wilhelm Dilg, Konrad Krez, Edmund Märklin, Ernst A. Zündt, Madame Anneke, Henrich von Ende, Julius Gugler, Georg Giegold, Louis Kindt.

Freidenker-Almanach. Milwaukee, Wis., 1878-1900, 23 vols.

Contains a large number of poetic, as well as prose contributions by Wisconsin writers.

The following comprises a list of the more prominent Wisconsin writers of German verse whose productions have not been gathered for publication in book form:

Anneke, Carl (Milwaukee).
Conze, Alexander (Milwaukee).
De Haas, Carl (Fond du Lac).
Ende, Amalia von (Milwaukee).
Fiebing, Bella (Milwaukee).
Grahamer, J. (Milwaukee).
Hotschick, George (Madison).
Huhn, Heinrich (Milwaukee).
Kindt, Louis (Racine).
Knotser, Emil (Milwaukee).
Pflaume, Karl (Manitowoc).
Ruppius, Otto (Milwaukee).
Trumpf, Gustav (Milwaukee).
Wintermeyer, Valentin (Manitowoc).

PEN NAMES.

(For a complete list of Wisconsin noms-de-plume, see Milwaukee Sunday Free Press, September 27, 1903.)

"Henricus vom See"—William Dilg.
"Onkel Karl"—Carl Doerflinger.
"Meik Fuchs"—Michael Jos. Lochemes.
"Arminius"—Herman Ruhland.
"Fridolin vom Wald"—Anton Thormaehlen.
"Ein Heimathloser"—Ernst Anton Zündt.

SOME HEPATICAE OF THE APOSTLE ISLANDS.

CHARLES E. ALLEN,

Assistant Professor of Botany, University of Wisconsin.

The following is a list of Hepaticae collected on two of the Apostle Islands, Lake Superior, between the 18th and the 28th of August, 1902. One day was spent on Presque Isle, the rest of the time on Madaline Island. Though this list by no means pretends to be complete, it is of interest to note, as showing the need of work with this group of plants, that of the twenty-one species enumerated below, six, Nos. 5, 6, 8, 13, 18 and 19, have not previously been reported to occur in Wisconsin.

Where the specific name used differs from that given by Underwood in the sixth edition of Gray's Manual, the latter is added as a synonym. "M." indicates the collection of the species in question on Madaline Island, "P." its collection on Presque Isle.

1. *Cyathophora quadrata* (Scop.) Trevis. *(Preissia commutata* Nees.) P.
2. *Marchantia polymorpha* L. Abundant. M.
3. *Riccardia latifrons* Lindb. *(Aneura latifrons* Lindb.) On a decaying log, with other Hepaticae. M.
4. *Pellia endiviaefolio* (Dicks.) Dum. P.
5. *Blasia pusilla* L. On damp clay in roadside ditches. M.
6. *Fossombronia foveolata* Lindb. *(F. Dumortieri* Lindb.) On damp rocks along shore. P.
7. *Jungermannia autumnalis D C. (J. Schraderi* Mart.) Common. M.; P.
8. *Lophozia ventricosa* (Dicks.) Dum. *(Jungermannia ventricosa* Dicks.) On soil and damp rocks. P.
9. *Lophocolea heterophylla* (Schrad.) Dum. Common. M.; P. P.

10. *Chiloscyphus polyanthos* (L.) Corda. Growing with *Mnium* on damp soil. M.
11. *Cephalozia curvifolia* (Dicks.) Dum. M.
12. *Cephalozia media* Lindb. *(C. multiflora* Spruce.) P.
13. *Cephalozia bicuspidata* (L.) Dum. On a damp stone in a bog. P.
14. *Bazzania trilobata* (L.) S. F. Gray. M.; P.
15. *Lepidozia reptans* (L.) Dum. M.; P.
16. *Blepharostoma trichophyllum* (L.) Dum. M.; P.
17. *Ptilidium ciliare* (L.) Nees. M.; P.
18. *Scapania nemorosa* (L.) Dum. On damp rocks, ground and decaying wood. M.; P.
19. *Scapania undulata* (L.) Dum. Carpeting rocks along the shore. P.
20. *Porella platyphylla* (L.) Lindb. P.
21. *Frullania Eboracensis* Gottsche. M.

SOME POINTS IN THE ANATOMY OF RANANTRA FUSCA P. BEAUV.

WM. S. MARSHALL AND HENRY SEVERIN.

Although the anatomy of *Ranantra* has already been described by Dufour (2) and by Locy (5) it appeared to us, after working for some time on this Hemipteron, that a further contribution could well be made, correcting some statements of these two workers, and on some points extending their observations. The specimens used were *R. fusca* and were all obtained near and in the city of Madison. They were all collected late in the autumn or early in the winter, the winter collecting requiring much time, it being found that at this time of the year *Ranantra* buries itself in the mud at the bottom of pools or creeks. The specimens were prepared by injecting alcohol into them, a hypodermic syringe being used, or cutting the body open before throwing them into the preserving fluid. With a few specimens a nearly saturated aqueous solution of corrosive sublimate was used which was well washed out before finally placing them in alcohol.

Alimentary Tract.—(Pl. XXXIV, Figs. 1 and 2.) The very thin oesophagus extends straight through the head and entire thorax, the diameter remaining the same throughout its entire length. At the posterior end of the metathorax there is a rather abrupt enlargement which marks the end of the oesophagus and the beginning of the mid-intestine. This second division of the alimentary canal is separable into two parts, the anterior extending in a straight course through the first three abdominal segments, the posterior being entirely within the fourth segment and longitudinally folded two or three times. These folds while, in general the same in their arrangement in all specimens, yet show quite an amount of individual variation. The next division, the ileum, passes through parts of the fourth

and of the fifth segments and opens into the posterior part of the rectum. The rectum extends forward beyond its union with the ileum almost to the preceding segment; in all fresh specimens it was filled with air.

A closer examination of the different parts of the alimentary canal, especially a study of sections, shows that there is at some places a sharply marked histological differentiation between them. The long thread-like oesophagus is of very nearly the same structure throughout its entire length; its diameter is at all parts very small and varies only at the extreme posterior end. The epithelial cells vary somewhat as to their relative length and breadth becoming very much longer at the posterior end, until finally just before the commencement of the mid-intestine, they are very long and narrow. (Pl. XXXIV, Fig. 3.) Internally the oesophagus is lined with a layer of chitin; externally there are two muscular layers. The outer of these, the longitudinal, varies in thickness in different parts of the oesophagus and is follwoed by the inner circular layer. Besides these two muscular layers there is a small amount of connective tissue scattered between the muscles, separating the two muscular layers from each other or from the layer of epithelial cells. This muscular layer shows quite a change in its thickness at or very near the point which marks the boundary between oesophagus and mid-intestine. In a longitudinal section of this part (Pl. XXXIV, Fig. 3) if one follows the muscular layer a sudden decrease in its thickness is noticeable, the change due apparently to a loss of connective tissue more than of the muscles themselves. In all specimens examined this change occurs very near the spot where the internal chitinous layer stops and where there is also a marked change in the structure of the epithelial cells. This point does not coincide with that at which the oesophagus begins to widen but is a short distance posterior to this, so what one would naturally consider, from an exterior view, as the boundary between the oesophagus and mid-intestine is in fact anterior to it. The cells of the oesophagus (Pl. XXXIV, Fig. 4), excepting the variations in shape, are similar, containing each a spherical nucleus and very often a number of vacuoles in the basal part of the cell.

The mid-intestine as seen in a dissection is readily divisible into two quite distinct portions, an anterior thicker part extending straight through the first three abdominal segments, and a

posterior one, lying within the fourth segment, which is much thinner and is thrown into longitudinal folds. (Pl. XXXIV, Fig. 5.) The anterior portion is laterally compressed and appears two or three times as wide from a lateral as from a dorsal view. The stomach has somewhat the appearance of being spirally coiled; this appearance is given to it by indentations arranged in part alternately on either side. The entire surface when examined with a lens has a roughened appearance, due to small papillae-like outfoldings which are very close together and cover the entire surface. In sectioning this part of the alimentary tract the layer of epithelial cells is found to be very much folded and it is the outpushing of these folds that causes the roughening of the surface. The epithelial cells are different from those of the oesophagus in that they have a general appearance of secretory cells and stain darker. The folding of the epithelial layer is characteristic for the entire mid-intestine and is found elsewhere in the canal, only in the posterior end of the oesophagus and here but slightly. The two muscle layers are present, the inner circular one has the fibres arranged in little groups and not in bands, as in the oesophagus. The posterior narrower part of the mid-intestine has the same external appearance as the anterior part, there being, however, a very abrupt decrease in the diameter of the canal where the two parts join. The folding of the epithelial cells is here not quite so marked as in the preceding part; the cells have the same appearance throughout the entire mid-intestine. Towards the posterior end of this section of the alimentary canal the circular muscles increase considerably in number, making this layer much thicker here than at any other part of the mid-intestine.

The next section, the hind-intestine, is easily separable into a thin anterior portion, the ileum, and a thicker posterior part, the rectum. At its anterior end, the ileum receives the Malpighian tubes and their entrance marks the boundary between mid- and hind-intestine. The thickness of the two divisions is about the same. The roughened external appearance is also missing, and the folding of the epithelial layer disappears rather abruptly with the ending of the mid-intestine. Histologically, there is a marked difference between this and the preceding division. The external muscular layers are both present, but very slightly developed; internally a thin cuticle is present. The epithelial cells show towards their free ends a marked longi-

tudinal striation which may be restricted to this part or extend further into the cell. The ovoid nuclei lie in the center of the cells, the basal end being normally rounded, but the end towards the free edge of the cell often has the nuclear membrane crumpled, giving to it the appearance of having been shrunken at this point by the preserving fluid. It is, however, noticeable that this irregularity when present is always at the same end. Each nucleus contains one or more nucleoli, and what is more noticeable, a peculiar hollow or cavity extending through it. (Pl. XXXIV, Fig. 6.) In transverse sections of the nucleus this appears as a large vacuole lying near its center; in longitudinal sections it varies somewhat, often extending straight through the nucleus, but more frequently it was curved, and if longer than the nucleus, bent upon itself. Within this hollow there was always present a brown rod-like body lying free within the cavity; it extended through it or was bent upon itself and then longer than the nucleus. In specimens stained with haematoxylin or with the safranin, gentian and orange triple stain, it remained of a light brown color. The whole nucleus reminded one of a gland, the wall of which would be represented by the body of the nucleus, the lumen, the hollow central cavity, while the rod-like body could be compared to the mass of secretion which had been contracted from the wall.

The rectum is in length nearly equal to the fifth segment of the abdomen; it lies ventral to the ileum and functions as an air bladder, being filled with air in all the fresh specimens we dissected. The ileum enters the rectum somwhat posterior to its center, the two being sharply contrasted both in external appearance and microscopic structure. A section shows that the wall of the rectum is composed of a layer of epithelial cells external to which is a thin coating of connective tissue. The epithelial cells contain each a nucleus but very little else, some having a small mass of protoplasm but never enough to fill the cell. The wall of the rectum in preserved specimens is irregularly folded, having the appearance of being easily distended and enlarged when filled with air.

Ranantra when free in water always rises to the surface with the posterior end much higher than the head. The end of the respiratory tube is then at the surface of the water, its normal position being one in which the tip of the tube reaches the surface, the rest of the insect remaining submerged. It retains this

position for some time and then may descend, or, allowing the body to rise, occupy a position nearly parallel to the surface of the water. The rectum filled with air acts as a hydrostatic bladder to carry the posterior part of the body up first. We do not see that there can be any other use for the rectum. The cells from their structure and evident lack of protoplasm could not serve any active function, and the absence of any except very small trachae would preclude the possibility of a respiratory function.

Salivary glands.—In a general dissection, dorsal view, the salivary glands appear as two tubes extending irregularly from a position near the center of the prothorax back to the anterior end of the thoracic ganglion. (Pl. XXXIV, Fig. 1.) An examination of a number of specimens shows that the glands vary as to their relative position to each other and to their entire length, some ending before the thoracic ganglion is reached, and others extending beyond its posterior margin, or in exceptional cases, to near the beginning of the abdomen. At the anterior end of each of these glands, there is a smaller one lying, in a dorsal view, entirely or partially concealed. Each small gland apparently unites with the large one near its anterior end, and from this union a single tube passes forward. A closer examination shows, as Dufour (2) has figured, that while each gland has its own duct and these join, yet they separate again and pass forward distinct from each other. An examination of glands, mounted *in toto*, and of sections, shows that each one consists of a median, longitudinal tube passing from one end to the other and surrounded by a single layer of acini, all sessile and opening into the central duct. The shape of the acini vary from those in the thicker parts of the gland with a round outline, to the elongated ones found in its narrower parts. Each acinus (Pl. XXXIV, Fig. 9) consists of a large central lumen partially or entirely filled with a granular secretion, and a wall composed of a number of flattened cells each of which contains a large nucleus. In the sections we studied it was impossible to distinguish any cell boundaries; the nuclei were very large, from one to four occurring in each section. Besides the cells of the smaller gland having a shorter diameter than those of the large one, there is noticeable in stained specimens a difference in color. In sections stained in haematoxylin followed by eosin, the contents of the smaller gland is nearly colorless but in the larger gland the

eosin has stained this part. This might lead one to hold that each gland secreted a different fluid, which view would be further shown by the presence of the two ducts, even if they did join at one point. We were unable to trace either duct further than the anterior part of the head and do not know whether they empty into the same or different places. From the anterior end of each gland (Pl. XXXIV, Fig. 7) there arises a duct which is a continuation of the longitudinal median tube already mentioned. The tube from the large gland, soon after its exit, widens, and in this widened part is a mass of cells, the nature of which we were unable to determine; it soon narrows again and at this point received the duct from the smaller gland. The single duct formed by the union is very short and divides to form the two long ducts passing forward into the head.

Locy (5) called attention to the similarity between the ducts of the salivary glands and the trachea, a comparison which at first is very striking. There is the transverse striation, due apparently to the taenidia winding spirally around the duct and having the glistening appearance so characteristic of the trachea. A longitudinal section shows, however, that this similarity does not remain. There is an internal chitinous layer (Pl. XXXIV, Fig. 8) quite wide and rigid internally, the alternate thick and thin layers giving of course the appearance of the taenidia, but yet quite different. Externally there is a thin chitinous layer and between the two a single row of flattened cells.

In the figures given both by Dufour (2) and Locy (5) there is seen on either side between the oesophagus and the salivary glands a long narrow tube extending for quite a distance backwards on the alimentary tract. On these tubes, at a place near the posterior end of the salivary glands, there is shown an enlargement which in the figures of both authors, is very noticeable. These are figured as the non-glandular portions of the salivary glands. In a general dissection these long tube-like bodies are seen at either side of the anterior portion of the midintestine and extend as far as the posterior end of the second abdominal segment. (Pl. XXXIV, Fig. 1.) They can be traced forward at either side of the oesophagus to the thoracic ganglion where each bends outward to pass around it. From here they run forward a short distance and then pass into a very long, thin duct, similar to those of the salivary glands, which extends into the head. Near the thoracic ganglion there is an

enlargement similar to that figured by Dufour (2) and by Locy (5), but not nearly so great.

A closer examination of one of these tubes shows that it cannot be a non-glandular portion of the silivary glands but is either an active part of this gland or a separate one, the use of which we could not determine. There are three distinct parts of the tube, the enlargement near th ganglion and the thinner parts lying in front of and back of this. The distal portion which extends through most of the metathorax and the first two abdominal segments is a narrow tube having the lumen about as thick as the two walls. Pl. XXXIV, Fig. 10 D.) The wall is composed of a single layer of what are apparently secretory cells resembling in general the structure of a Malpighian tube. The proximal portion, extending through the meso- and pro-thoacic segments is the narrowest part and closely resembles the ducts leading from the salivary glands. It extends forward into the head, but its outlet we were unable to discover.

The enlarged middle portion is peculiar in its structure and differs from either of the other parts. A view of a mounted specimen shows us that the distal portion gradually passes into it with very little change in the general appearance except an increase in size. There are, however, a number of longitudinal strands passing partially through it. (Pl. XXXIV, Fig. 10 Str.) Towards its proximal end these strands in part disappear, the cells become smaller and more closely packed together, and this entire part is stained very much darker than any other portion of the tube. A longitudinal section of this median portion (Pl. XXXV, Fig. 11) shows the wall to be continuous throughout. The strands pass forward into the darkly stained part where they apparently become closely packed together and lost. The cells and the nuclei become smaller and a mass of cells is formed which fills the lumen and even extends for a short distance into the tube. There is certainly no structure similar to this in the salivary glands, and whatever the function of this tube may be it does not act as a reservoir for the salivary glands, but is more likely a part of the salivary gland or a special gland.

Respiratory System.—(Pl. XXXV, Fig. 12.) One of the most noticeable features of *Ranantra* is the presence at the posterior end of the two long caudal filaments which together form the so called "respiratory tube." As already explained, when the insect rises to the surface the posterior end is much higher than the

anterior and the tip of the "tube" reaches the surface of the water first. If a specimen of *Ranantra* in this position is watched, it is noticed that soon after the tips of the caudal filaments reach the surface a film of air is seen between them and this can be either the air expelled from the body or the fresh air being drawn into the trachae. We carried on a few experiments to determine the necessity of the "respiratory tube" and what effect an injury to this part would have upon the insect. Several specimens were first taken and the "tube" of each cut partially off, the amount removed being different in each case. These were then replaced in small aquaria and all of them lived for several days, no difference in the length of life being noticeable between these and normal specimens living in the same or similar aquaria. Two specimens had the entire "tube" removed, and also the stigmata on the filaments and a small part of the trachea and yet the insects lived for a number of days. Two normal specimens were placed each in a bottle of water and in one case a cork was placed so that it rested on the surface of the water, in the other paper was used. One of these died in four or five hours and the other was not seen again until the next day, when it too was dead. The length of the "tube" allows the insects to remain farther away from the surface and the better concealed, but respiration can be carried on just as well with a very short as with a long "tube." An examination of the caudal filaments after they have been cleared and mounted shows that the stigmata which are used by the insect when submerged are situated one near the proximal end of each filament. Comstock (1) says that the filaments conduct "the air to two spiracles situated at the caudal end of the abdomen," a view not given by Locy (5) who correctly says that the stigmata are on the filaments.

From the stigma at the base of each filament there passes forward a trachea which, surrounded by a part of the fat body, extends through the abdomen, giving off a number of branches to supply the different parts of the body. (Pl. XXXV, Fig. 12.) There are on the abdomen three pairs of stigmata, a pair to each of the following segments; the third, fourth and fifth. When the abdominal tracheal tubes reach the posterior end of the metathorax, each divides into two branches, the outer of which bends towards the side of the body and connects with a stigma which is situated at the posterior lateral edge of the metathorax. The inner loops bending slightly towards the central

part of the body pass forward and, just before reaching the mesothorax, they in their turn curve towards the sides of the body. At this point each gives off a branch which passes forward through the muscles to which they give off a great many small branches. After this branch is given off, the trachea continue in their course towards the side of the body, but before reaching it each divides into two branches, one passing backward to join the metathoracic stigma, the other branch passing forward to enter another stigma situated at the posterior lateral edge of the mesothorax. From each of the last stigmata a large trachea passes forward along the side of the body and in the posterior end of the prothorax joins with the branch we have already mentioned as passing through the muscles. There is thus formed at either side a large dark trachea which passes through the prothorax, and at its anterior end divides into two branches, the inner of which passes forward into the head, the outer entering the anterior pair of legs.

The connection between the trachea of the abdomen and the stigmata is not clear. When the stigmata were cut out, cleared and mounted, a small trachea could be seen coming from each, which undoubtedly led into the main trunk.

We have already mentioned that the rectum is filled with air and has a hydrostatic function. There are also present in *Ranantra* two pairs of air sacs very noticeable when fresh specimens are used. We were unable to trace these to their origin and do not know from what part of the tracheal system they arise. Each is a thin walled sac easily collapsable and without any resemblance to a trachea. The anterior pair, as far as we could make out, arise ventrally in the anterior part of the head and extend backward to near the middle of the prothorax. The posterior pair we could trace forward to about the middle of the prothorax and near its ventral wall. From here they pass backward above the intestine often extending as far as the fourth abdominal segment.

Locy (5) mentions that when *Ranantra* is preparing for flight, these air sacs are filled. As to this we can not say but know that all specimens taken from the water had the sacs partially or entirely filled with air. In reaching the surface of the water, the insects rise with the head down, but do not always remain in this position. We noticed that many in a short time assumed a position very nearly parallel to the surface of the

water, and it may be that these sacs are used to bring the insect to this position.

Nervous System.—(Pl. XXXV, Fig. 13.) The supra-oesophageal ganglion is situated in the posterior part of the head; it shows dorsally a median longitudinal furrow which makes it easy to distinguish a right and a left lobe. From the posterior end of each lobe passes a circum-oesophageal commissure, the two uniting in the infra-oesophageal ganglion which lies at the extreme anterior margin of the prothorax. The remaining ganglionic system of *Ranantra* is represented by but one other large ganglion situated mostly within the mesothorax but extending backward for some distance into the metathorax. This single thoracic ganglion is connected with the infra-oesophageal ganglion by two long, thin cords while from its posterior end arise the two nerve bundles which, passing backward, supply nearly all parts of the abdomen.

In a general dissection there is but little to notice except the branches coming from the thoracic ganglion, and the nerves given off from the two main trunks of the abdomen, all of which is shown in Pl. XXXV, Fig. 13. In a microscopic preparation of the entire nervous system, each of the two strands leaving the posterior partof the thoracic ganglion appears single and not divided into parts. After the first nerve has been given off, the main strand shows a distinct division into four parallel strands, the presence of which is only seen in stained and mounted preparations. Soon another nerve is given off and then the main branch shows three separate strands for some distance, a fourth, however, appearing. These four remain together until the next branching, when there appears a division into two parts, each containing two of the four strands. This is really a splitting of the main nerve, but one is larger than the other and remains as the main trunk, the other appearing as a branch which leaves as the other branches have done and passes towards the side of the body. Between this branch and the main nerve, the oviduct passes. The main trunk with its two remaining strands continues towards the posterior part of the body and when the next nerve is given off divides so that one strand remains as the main nerve and the other passes off as a branch. The single strand of which the main nerve is composed divides so that there are again two strands in it before the next and last noticeable nerve is given off.

The thoracic ganglion cleared and mounted whole or sectioned horizontally shows that it is composed of three fused ganglia. (Pl. XXXV, Fig. 14.) The first and second of these are similar in shape, showing quite an anterior-posterior compression and differing but little in size, the anterior slightly the smaller. Each gives off three rather large nerves from either size, the first receiving the two long nerves from the infra-oesophageal ganglion, and the third giving off the two main trunks from its posterior end. The last (third) part of the ganglion is elongated along its longitudinal axis. The two large nerves coming from it do not arise from a single root as shown, (Pl. XXXV, Fig. 14) but each has as its origin several small roots, most of which arise from the posterior margin of the ganglion, but at least one further forward than these, and on the side. The position of the ganglion cells is shown in the cut.

In connection with the nervous system, we would mention the sense-organs in the antenna. (Pl. XXXV, Fig. 15.) In endeavoring to make a section of the head, the tip of one of the antennae, which had been cut partially open, was noticed on the slide. Along one edge there was a row of setae closed at their tip, but each resting on a little papilla slightly raised from the surface. At the base of each seta was a sac hanging free within the antenna. These sacs each received at its base a fine nerve which came from a ganglion in the base of the terminal joint of the antenna. Within each sac was a structure having the appearance of a small ganglion. At the base were a number of nuclei, the rest of the sac being filled with fibrillar substance from which fibrils entered the base of the seta. (Pl. XXXV, Fig. 16.)

Reproductive organs; male.—The two testes are found principally within the second abdominal segment but generally extend a short distance forward into the preceding one. (Pl. XXXV, Fig. 17.) From a dorsal view each testis appears as an elongated body pointed at both ends, the posterior blunter than the anterior, with a vas deferens arising from the posterior end of each. A closer examination shows at once that the dorsal view does not, as a rule, reveal the true shape, because, in most specimens examined, one part of the testis is concealed. When all the parts are seen (Pl. XXXVI, Fig. 18), the general shape does not become changed but we find that about two-thirds the distance from the anterior end there is a large projection from the wall of the testis, and that it is here the vas deferens has its origin.

The vas deferens passes backward as a narrow tube nearly through the third segment, when it widens considerably and remains so as far as the middle of the fourth segment. This enlarged part, the seminal vesicle (Pl. XXXVI, Fig. 19), becomes very much twisted and often forms for its entire length an irregular spiral. The duct leaving the seminal vesicle is thicker than when it enters it, and in a short distance unties in the median line, with the duct from the other testis. The short single tube thus formed, the ductus ejaculatorius, enters the base of the penis.

Each testis shows the two ends somewhat different, the anterior is the more pointed and often ends in a short thread-like terminal filament; the posterior end is much blunter and in some specimens it had the appearance of being spirally coiled, but only once as markedly so as represented in (Pl. XXXVI, Fig. 18). The projection from the ventral surface of the testis which we have mentioned, is a little nearer the posterior than the anterior end; it is made up of six parts, the bases of the seminal follicles, which disappear in the body of the testis, and at their proximal ends unite to form the vas deferens. The testis is composed of the six follicles enclosed in a common scrotal membrane. When separated from one another, each follicle consists of this thickened, projecting, basal piece and an elongated thinner tube, which in sections, is seen to contain the different stages of the developing spermatozoa. The relative lengths of these two parts we were unable, from our alcoholic specimens, to determine, but from the figures given by both Dufour (2) and Locy (5), the thick basal portion is but a very small part of the entire follicle. A section through the testis shows these follicles to be packed closely together.

In the seminal vesicle we found that the wall changed very little but that the lumen became much enlarged and was, in all specimens examined, filled with spermatozoa. The tube might coil somewhat regularly for its entire distance or loop back and forth on itself from one end to the other, the most common occurrence being, however, a mixture of the two, with the coils predominating. Sections showed the wall to consist of a single row of epithelial cells (Pl. XXXVI, Fig. 20 A) with a thin layer of connective tissue at their base. The nuclei were fairly large and spherical.

The vas deferens emerging from the posterior end of the

seminal vesicle differs from the anterior section both in thickness and in its cellular structure. In sections (Pl. XXXVI, Fig. 21) it is seen that two muscular layers are present, an outer longitudinal, and an inner circular one. There is a single layer of epithelial cells, each with a small spherical nucleus near its base and cell boundaries which were discernible only for about one-third the distance from the basal membrane to the free end of the cell. Here the boundaries disappeared, some at a greater distance from the base than others, so that no limit to the cells could be distinguished. There was apparently quite a difference in the structure of the cell at different parts, the distal half showing a number of large vacuoles which are not present near the base, and also showing very distinctly a longitudinal striation. The lumen of the tube was very small or often not discernible. Where the lumen had disappeared, its position was filled with a mass which was seemingly a continuation of the cells and differed from them only in the direction of the striation. When a longitudinal section of part of the tube is seen, the striations nearest the base are at right angles to the wall of the tube, but towards the center they all turn in one direction as if there was a flowing out from the tube. The cells have a glandular appearance and it would seem that the secretion formed was filling or had filled the lumen of the tube and was being carried slowly to the outside.

This last part of the vas deferens is short, and, uniting with the one from the other testis, forms a short median tube, the ejaculatory duct, which passes into the base of the penis. The structure is here different from any other part of the tube. The epithelial cells are small and nucleated and between them we were unable to distinguish any boundaries. The free ends of the cells were lined with a wrinkled layer of chitin, while at their base was a thick layer of circular muscles. These entirely surrounded the epithelial layer and made up most of the thickness of the wall.

Reproductive organs; female.—(Pl. XXXVI, Figs. 23, 24.) Each ovary consists of five ovarian tubules each with a terminal nutritive chamber followed by a number of egg chambers. The five nutritive chambers are situated within the first abdominal segment; they are held together by tracheal tubes and connective tissue, making it very easy to remove the tubules of each ovary as one piece. In all our specimens, collected in autumn, the tubules

were empty for about the posterior third of their length and none contained any fully formed eggs. Near the posterior end of the third abdominal segment the tubules of each ovary unite to form the oviduct, each tubule, just before its union with the others, forming a loop or bend. The two oviducts gradually converge and meet at the posterior end of the fourth segment where they join and form the larger common oviduct which extends backward to the end of the body. Within the fifth segment and generally to the right of the oviduct is a partially coiled tubular gland which empties ventrally into the oviduct near its end.

Each ovarian tubule shows that anterior to the nutritive chamber there is a long terminal filament passing forward into the thorax and attached to the muscles in the mesothoracic segment. Korschelt (4) has described the minute structure of the ovary of *Ranantra linearis,* and we will give but a brief description of our species. The nutritive chamber (Pl. XXXVI, Fig. 25) excepting a small space near the proximal end is filled with a mass of cells. These are smallest at the terminal end, they gradually increase in size towards the basal end, and within a short distance of the first egg chamber several very large cells are noticed, each one undoubtedly destined to become an egg. The arrangement of the cells in a definite epithelial layer was noticeable only near the basal end. Near the center of the basal end there is a granular mass which has a number of processes extending towards each end of the egg. Those towards the anterior part become lost in the cell mass, but those going in the opposite direction form the nutritive tubes, each one of which passes to an egg-chamber. The nutritive chamber is quite similar to that described by Gross (3) for *asopus bidens.* The first of the egg chambers is very small but they gradually increase in size. Besides the follicular layer surrounding the string of egg chambers, there are two thin layers surrounding each tubule. The gland passing into the oviduct is very narrow. Its wall (Pl. XXXVI, Fig. 26) consists of an external layer of longitudinal muscles and connective tissue and an internal layer of epithelial cells. These are of two kinds, differing apparently only in their thickness. Near the free edge of the cells there is a peculiar serrated appearance showing a lighter margin into which processes of the more deeply stained protoplasm protude.

Within the prothorax there are a number of muscles which are very noticeable when this part of the body is opened. (Pl.

XXXVI, Fig. 27). There are two pairs near the center of the body (figured by Dufour (2)) both arising on the chitinous plate which partially separates the pro- from the meso-thorax. One pair has a dorsal, the other a ventral origin, and from them tendons run forward to be inserted at the base of the head. They are used in lifting and lowering the head. At each side of the prothorax are two other muscles arising from two chitinous protuberances at the posterior end of the prothorax. Each muscle has a tendon running through it, they being inserted at the base of the first pair of legs. They are used in extending and flexing the front legs.

Zoological Laboratory
University of Wisconsin,
Madison, February, 1904.

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PLATE XXXIV.

EXPLANATION OF PLATE XXXIV.

All figures except general dissections drawn with a camera. Magnification in diameters given after explanation of each figure.

Fig. 1. Dorsal view of alimentary tract and salivary glands; oes., oesophagus; Sl. G., salivary gland; the smaller one seen at its anterior end. G. F., so-called receptacle of salivary gland. M. I., mid-intestine. Mlp., Malpighian tubes. Il., ileum; R., rectum. × 3.

Fig. 2. Alimentary tract without the oesophagus, showing relative length of different parts. Lettering as above. × 3.

Fig. 3. Longitudinal section through posterior end of oesophagus with a very small part of the mid-intestine the epithelial cells of which have not been drawn. ch., chitinous layer. C. M., Circular muscles. L. M., longitudinal muscles. × 220.

Fig. 4. Three cells of the oesophagus, the muscular and chitinous layers omitted ext., external surface. × 1000.

Fig. 5. Longitudinal section through part of mid-intestine, larger anterior part, to show folding of epithelial layer. L. M., longitudinal muscles. C. M., circular muscles. ext., external surface. × 220.

Fig. 6. Three cells of the ileum. ext., external surface. × 315.

Fig. 7. Showing the anterior ends of a salivary gland with the two terminal acini of L. G., the larger, and S. G., the smaller gland. The duct from the larger gland is seen to receive that from the smaller one and then to divide again. × 92.

Fig. 8. A longitudinal section of the duct of the salivary gland. The part cut is between the two lines marked a in fig. 7. The chitinous layer having the serrated appearance is internal. × 1000.

Fig. 9. Section of a single acinus of the salivary gland. × 150.

Fig. 10. Part of the so-called receptacle of the salivary gland; above the terminal portion (sectional view); at D, the distal portion. M., the enlarged median portion, showing the strands, Str. P., part of the proximal portion. × 26.

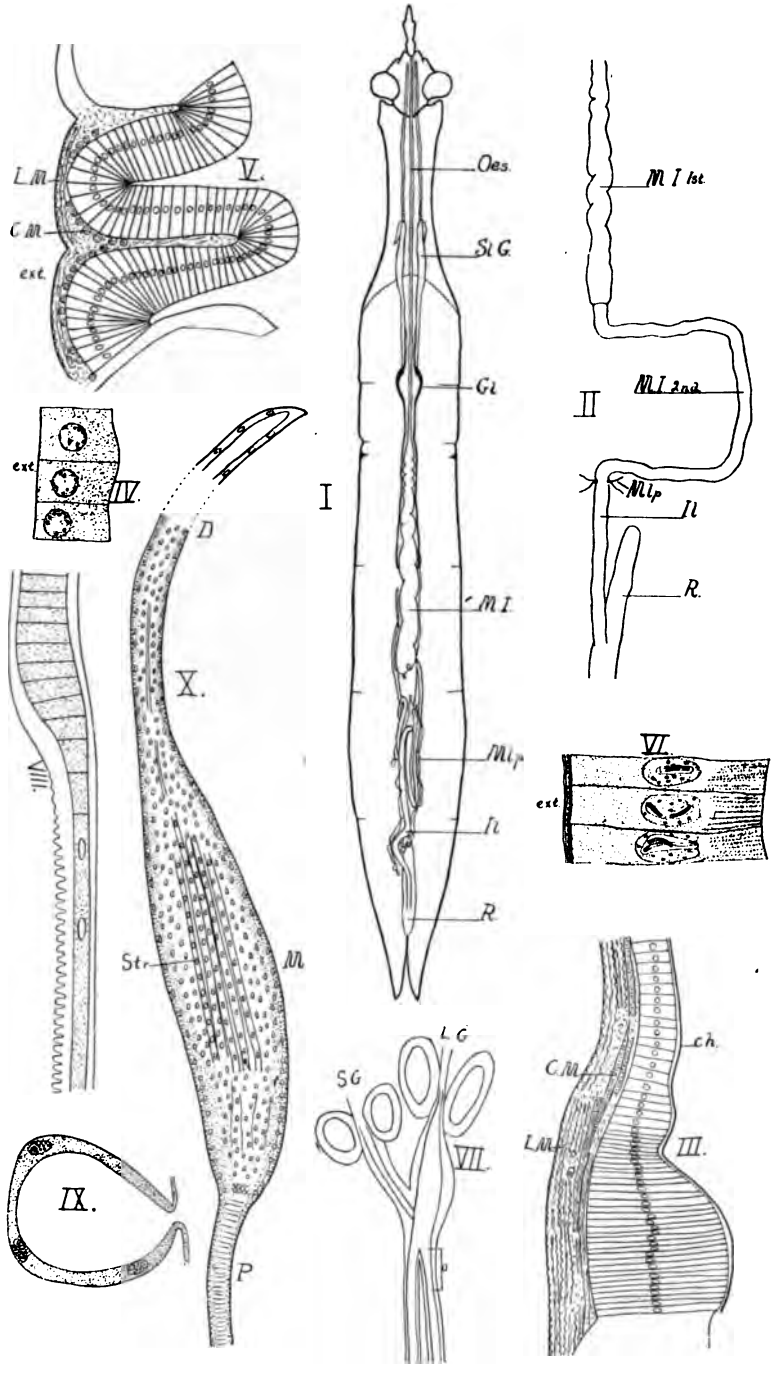

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PLATE XXXV.

EXPLANATION OF PLATE XXXV.

Fig. 11. Longitudinal section of same. str., strands passing through the center. D., distal; M., median, and P., proximal portions. Just below the center the massing of the cells is shown and their gradual decrease in size. × 300.

Fig. 12. Dorsal view showing the tracheal system and the two pairs of sacs which are dotted. a., mesothoracic stigmata; b, metathoracic stigmata; c, d, e., the three pairs of abdominal stigmata. f., stigmata on caudal filaments. tr., 1, trachea to head; tr., 2, to front pair of legs. tr., 3, to intestine. tr., 4, to reproductive organs. tr., 5, trachea, the upper branch of which goes to the fat body, the lower branch to the intestine. tr., 6, to intestine. × 3.

Fig. 13. S. O. G., supra-oesophageal ganglion. I. O. G., infra-oesophageal ganglion. T. G., thoracic ganglion. P., prothorax. Me., mesothorax. Mt., metathorax. Ov., where ovary passes between main nerve trunk and the largest branch. × 3.

Fig. 14. Horizontal section of thoracic ganglion, showing the three ganglia of which it is composed and the principal nerves arising from it. A., anterior. B., posterior. × 46.

Fig. 15. Terminal joint of antenna showing sense-organs. × 92.

Fig. 16. Single sense organ. × 630.

Fig. 17. Male reproductive organs. T., testes. V. D., vas deferens. S. V., seminal vesicles. D. J., ejaculatory duct. × 2.

Fig. 18. Testis. F., basal portion of seminal follicle. V. D., vas deferens. × 26.

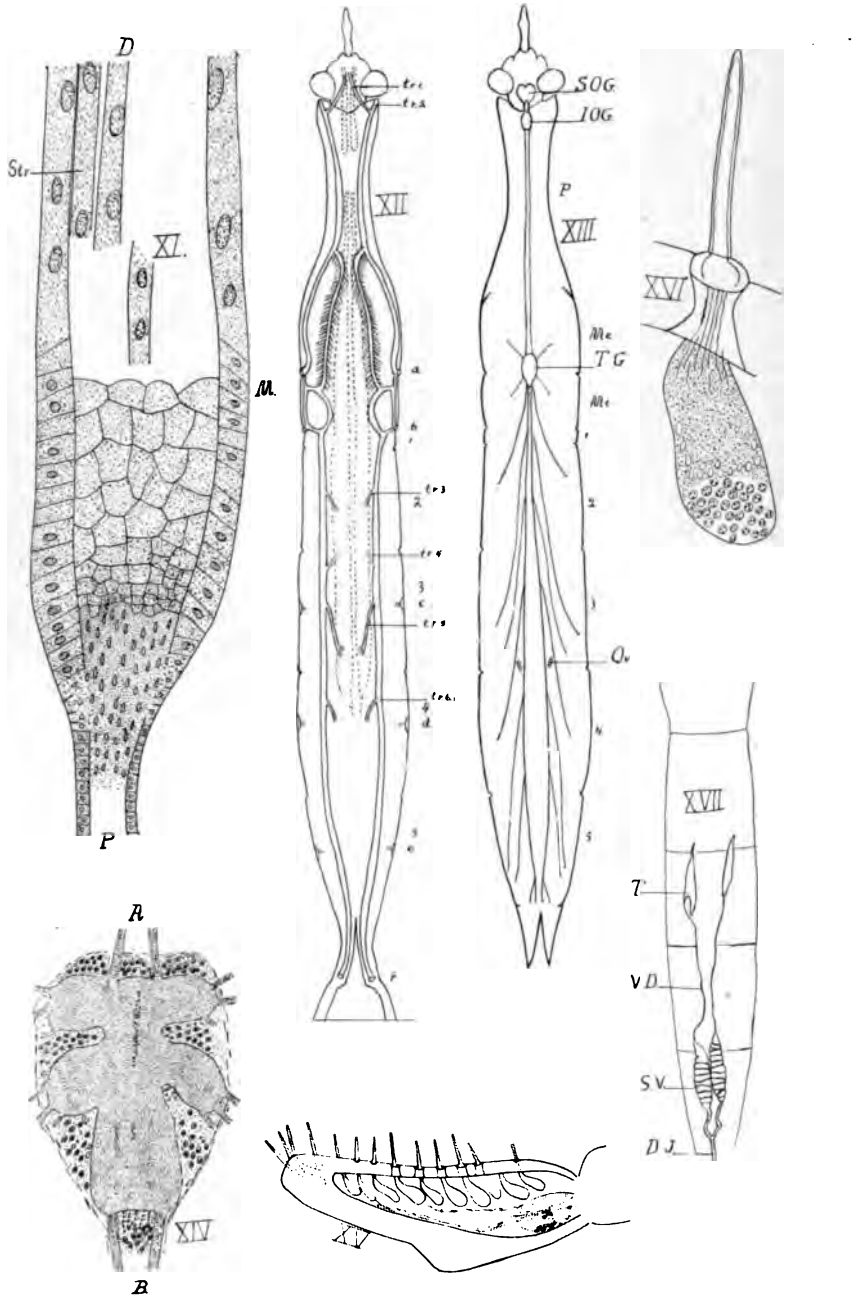

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PLATE XXXVI.

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EXPLANATION OF PLATE XXXVI.

Fig. 19. Seminal vesicle. × 26.

Fig. 20. Basal portion of seminal follicles. Only four of the six seen. × 20.

Fig. 20 A. Section through wall of seminal vesicle, base of cells to left. × 1000.

Fig. 21. Longitudinal section of wall of the vas deferens below the seminal vesicle. To the left base of cells; the longitudinal and the circular muscular layers are shown. ×630.

Fig. 22. Transverse section through the ejaculatory duct—but half the duct shown. Within, to the left, the chitinous layer followed by the layer of epithelial cells and the circular muscles. × 630.

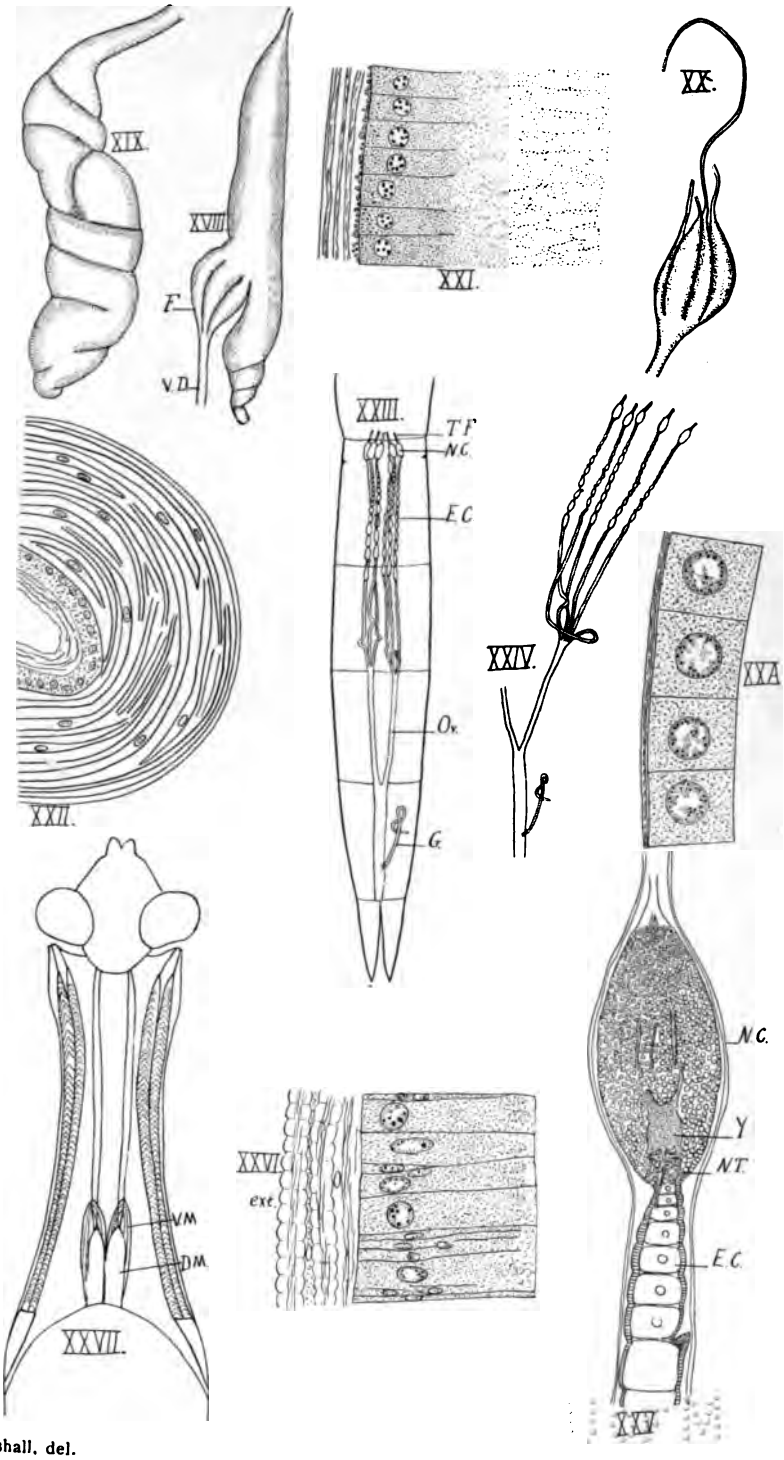
Fig. 23. Dorsal view showing female reproductive organs. T. F., terminal filaments. N. C., nutritive chambers. E. C., egg chambers. Ov., oviduct. G., gland. × 2.

Fig. 24. The five ovarian tubules of an ovary dissected apart. × 2.

Fig. 25. Longitudinal section of a nutritive chamber and of the first of the egg chambers. N. C., nutritive chamber. Y., central yolk mass. N. T., nutritive tube leading from yolk mass to one of the egg chambers. × 37.

Fig. 26. Longitudinal section of wall of the gland, G., in figure 23. ext., external surface. × 630.

Fig. 27. Dissection of muscles of the prothorax. V. M., the dorsal pair of central muscles which raise the head. D. M., the ventral pair. On either side are seen the two muscles which pass to the anterior legs. × 6.



W. S. Marshall, del.

Mau

AUDITORY MEMORY SPAN FOR NUMBERS IN SCHOOL CHILDREN.

JOHN I. JEGI.

Late Professor of Physiology and Psychology, Milwaukee Normal School.

The problem for this study was to determine the native memory power in children between the ages of five and fifteen years, or as we find them in the grades from the first to the eighth inclusive. Does memory power increase at a uniform rate from age to age as shown by the number of different things a child can retain and reproduce? Does it increase more rapidly at some ages than at others? Do the many things a child has to remember increase his native memory power? What may we regard as the actual memory span in children throughout the grades? Is there a "memory period" as such during which this power suddenly and rapidly blossoms out and shows itself in a remarkable increase of native power? This investigation was undertaken to throw some light on these and kindred questions relating to this very important power of the human mind. The study is limited, however, to a single one of the six modes or forms of impression—the auditory, and to a single one of the scores of objects that may be remembered—numbers.

Several studies have been made which throw some light on some of these questions, but memory span as such in school children has not been studied directly so far as I know. Mr. F. W. Smedley, Director of the Department of Child Study and Pedagogical Investigation, of the Chicago Public Schools, gives a table of memory span in the third report (1900–1901), but the method he used could not be expected to yield very accurate results, and besides he attempted only to determine some simple standard for comparing memory power in abnormal children whom he was studying and not to ascertain the actual span for

large groups of normal children by methods devised expressly for this purpose. In the other studies on memory no attempt whatever was made to ascertain the comparative strength of memory or the rate of growth of memory power for the various ages represented in the school period.

Method. The nine significant digits were grouped in series of various lengths ranging from four to nine figures each. An effort was made to avoid as far as possible all previously established associations in arranging the digits for these series, and a sufficient number of series was prepared to avoid repeating any series with the same pupil.

All of the tests were made on a single child at a time; and no visitors, listeners, or lookers on were permitted to be present at any time. In this particular my study differs from the others thus far reported in which all of the pupils of a room were tested at the same time. Series of numbers were read to each child in a pleasant, agreeable, but firm, and business-like tone of voice, and at a rate that seemed to suit each child best, a metronome being used to keep the rate absolutely uniform after it had once been established for each child. I may say that the rate did not vary widely as a general rule and yet there were some marked deviations from the rate used in the room-tests made by Prof. Smedley. Children show their individuality in this as well as in all other matters.

Short series were used at first so as to keep clearly within the memory span of the child and thus serve to call his attention to his own power to reproduce numbers; in this way the child was encouraged to do his very best in the subsequent longer series which were gradually introduced. Five series of a set of given length were read in succession and then the next longer was used in the same way and this was continued until a set was reached which the child was unable to reproduce accurately, i. e., in five successful trials—making no error in the figures nor in their order. The longest series that a child could reproduce correctly in five consecutive tests was taken as his memory span. In many cases a longer series was occasionally correctly repeated, but in every case the next shorter series was regarded as his limit unless on a subsequent day he reproduced the longer series correctly five times in succession.

Each child was tested on two different days and in some cases a third and even a fourth test was made. An effort was made

to catch each child at his very best, and then to inspire him to do his very best to reproduce correctly the longest possible series. The children seemed greatly pleased with the experiment and expressed considerable interest in their native power of memory. I may safely say that these children did the best they could. In this way about three hundred children were tested, ranging in age from five to fifteen years inclusive.

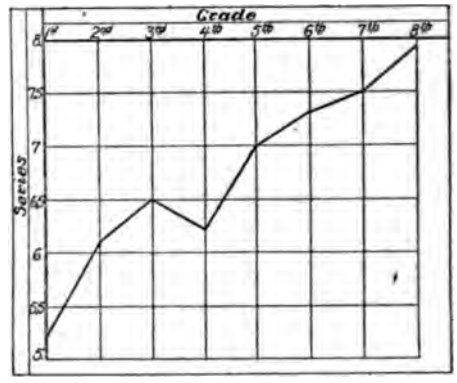
It may be of interest to say that in the beginning it was my purpose to test each child in the morning before school opened and again immediately after the close of the afternoon session so that the difference due to the fatigue of the regular school work might be taken into account. At the same time I was carrying on another investigation on quickness and accuracy of number perception using another group of school children. In both of these studies it was very evident from the first that the results were just as good at the close of the school day as at the beginning, and where there was a perceptible difference the afternoon tests were in the lead. The fatigue resulting from the school work seemed to have no effect whatever on the memory span, or on the quickness and accuracy of number perception, as revealed by the results of these two investigations. Most of the children, however, preferred the morning tests and thought that they did better in these than in the evening tests, and they were quite unanimous in saying that it was much easier in the morning. The evening tests seemed to require greater effort on the part of the children, but in no case were the results inferior to those obtained in the morning tests.

Results. The actual memory span as obtained in this investigation is indicated on the charts and in the tables below.

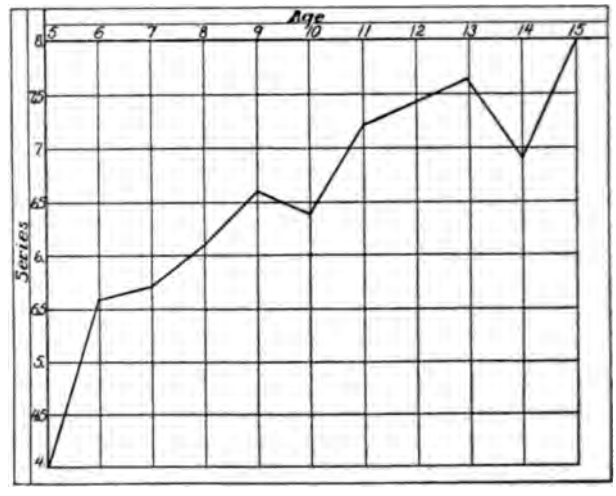
1. The reader will observe that the rate of increase in memory power is practically uniform from 7 or 8 to 15 years of age, and that it is somewhat more rapid in the earlier years.

2. The reader will notice further that these curves do not indicate that there is a time in the child's development when there is a great or sudden increase in memory power, no "period of memory" so far as rapid growth of this power is concerned.

3. The curve shows that the memory span increases from 4 at the age of five to 8 at the age of fifteen, i. e., the memory span is doubled during the eleven years from five to fifteen. Grouping the children as we found them in the eight grades, the increase is from 5.2 in the first grade to 7.9 in the eighth grade.



Auditory Memory Span by Grades



Auditory Memory Span by Ages

4. The actual memory span by ages is as follows:

4 at the age of five years.
5.6 at the age of six years.
5.7 at the age of seven years.
6.1 at the age of eight years.
6.6 at the age of nine years.
6.4 at the age of ten years.
7.2 at the age of eleven years.
7.4 at the age of twelve years.
7.6 at the age of thirteen years.
6.9 at the age of fourteen years.
8.0 at the age of fifteen years.

5. The actual memory span by grades is as follows:

5.2 for the first grade.
6.1 for the second grade.
6.5 for the third grade.
6.2 for the fourth grade.
7.0 for the fifth grade.
7.3 for the sixth grade.
7.5 for the seventh grade.
7.9 for the eighth grade.

6. This test has to do only with mechanical memory and not with rational, logical, or associational memory; with native, crude, inherited power and not with skill resulting from school training or previous acquirements; with power or capacity as such and not with knowledge or facts the resultants of individual experience.

7. In this study and in all similar investigations it is quite impossible to abstract attention from native capacity to retain and recall, and hence we must make an allowance for or take into account the child's increase in power of close attention; and it may be that the increase in memory power is little more than ability to hold the mind more and more closely to the work to be done; if this view be accepted then we are testing native memory power as colored by the gain in attention from age to age and from grade to grade.

Milwaukee Normal School, Dec. 30, 1903.

A TREATMENT OF INSTANT ANGULAR AND LINEAR VELOCITIES IN COMPLEX MECHANISMS.

OLIVER B. ZIMMERMAN,

Assistant Professor of Machine Design, University of Wisconsin.

To the engineer, it is usually desirable, in the treatment of kinematic motions, to obtain as simple and direct a solution of the problem as is possible. This simplicity requires either a rapid graphical solution or the simplest of equations to represent the relations that exist between parts of a mechanism, whatever these relations may be.

It is to present a treatment of angular and linear velocities, somewhat different from that usually given that I submit the following. This method of solving such problems, especially those of a complex nature, has been used by the classes in engineering kinematics for the past three years, and has been found more satisfactory than the older geometrical solutions.

In Fig. I, take the four link, crossed link mechanism A. B. C. D., links A and B equal in length to C and D respectively, hold A stationary and follow the motion of C, keeping links B and D crossed throughout the motion.

We understand from our knowledge of centros that all points in C roll with respect to A about the instant center *ac*. Follow the path of this instant center and it will be found to describe, under the conditions named, the two elliptical centrodes, the body centrode and the space centrode.

We know further that if the two links B and D be removed, we can produce the same relative motion between links A and C if we replace links B and D by the two centrodes which point *ac* describes during its motion, and roll them together without slip. We can state also that links A and C are lines upon the

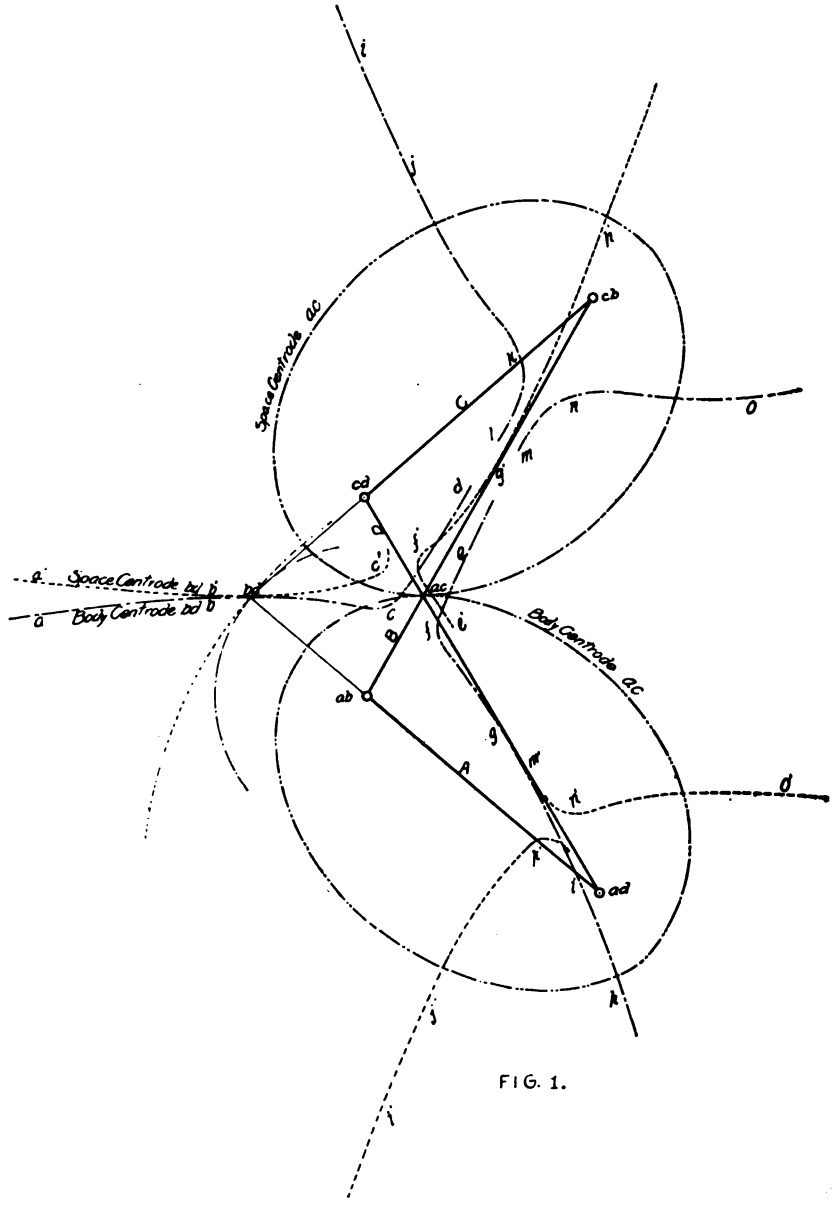

Space Centrode ac
Space Centrode bd
Body Centrode bd
Body Centrode ac
cd
ab
ac
bd
ad

FIG. 1.

ntrodes of A and C, or that links A and C are in form the me as that of the rolling centrodes moving one upon the other ithout slip.

The case of relative motion of links A and C in this mechan-. m is simple; but if we attempt to see the relative motion be-reen the two links B and D—the exceedingly complex cen-odes make it quite out of the question to follow the rolling otion as such. The centrodes pass to infinity plus and minus, id do not show outwardly the angular motion. The various ossible ways of passing the dead centers produce various curves etween the points lettered c' and e', also k' and n', of space ntrode *bd;* and in the body centrode *bd,* between the points and e, also, l and m.

When three bodies move in the same plane, as A; B and D, ich moves with respect to the other about some point, and the ree centers or centros *ab, ad* and *bd* must lie in the same raight line.

The point *bd,* is the point of contact of the two centrodes of and D, or as was stated above, the centrodes may be considered panded links, point *bd* may be said to be the contact point, or mmon point of the two links B and D. As a point in each link must of necessity travel about the center of rotation of that nk with respect to the stationary body. Also, since *bd* is a mmon point to the two links, *bd* must be a point, when con-dered in each, which has the same velocity about either center rotation. In general, then:—the directional motion and elocity of points in the centrodes which come in contact, are ie same.

During the motion of any mechanism, two facts, first:—that ie directional motion of the contact points of the centrodes hich roll together, is perpendicular to the line of centers, and econdly, that their velocity is the same, as each of these points the centrodes comes in contact at the centro, enable us to ake this deduction:—

"We may replace the complex centrodes by a simple pair of ntrodes in the form of circles, which circles roll together ithout slip and have the property of expanding and contract-ig, each independently, opposite to one another, or together cording to the same law as the contact points of the regular ntrodes."

The above named circles will always be in contact at the

common point of the two moving links under consideration, and will have their centers at the centers of rotation of these links with respect to the stationary link.

To illustrate: In Fig. 1. Take the three links A, B and D. Let A be stationary. Then B and D will be the two moving links. All points in D revolve about *ad* with respect to the stationary link, all points in B about ab, and all points in B and D revolve about the point *bd* with respect to each other, *bd* being the point common to the two moving links.

I may substitute then, for the two complex centrodes, the two circular centrodes, which will also be in contact at *bd* and will rotate about the centros *ad* and *ab* respectively.

Fully grasping this relation enables one to more readily understand this type of problems, and one can therefore read, with equal ease, the relative angular velocity ratios of any two links in any mechanism, however complicated, however widely separated the links may be and whatever link may be held stationary.

When the centros do not fall within the limits of the drawing, an application of the more common geometrical solutions is employed with greater facility when the above development is understood.

The relative directional rotation of the two links is also instantly recognized by noting the position of the contact points of the two moving links with respect to their centers of rotation.

In Fig. 2 as the mechanism moves from position 3 to position 1, the two rolling circles or centrodes, which are substituted for the more complex ones, expand from the two circles in contact at bb', through position aa' to ll', and as in rolling circles "The angular velocity ratios of the two centrodes (hence of the two links) are to each other inversely as the radii of the rolling centrodes measured from their common centro to their respective centers of rotation." Ratio $V°b'$: $V°b$:: Distance between points bb' and ab: Distance between points bb' and ab' or

$$=\frac{bb'-ad}{bb'-ab'}$$

the sign — meaning "distance between."

Likewise since in position l and l' the point ll' has the same velocity whether considered a point in link l or l', "the velocity of any two points in any two links may be compared by finding

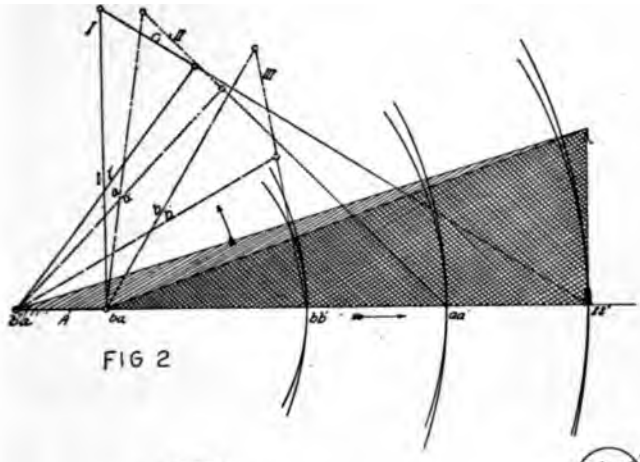


FIG 2

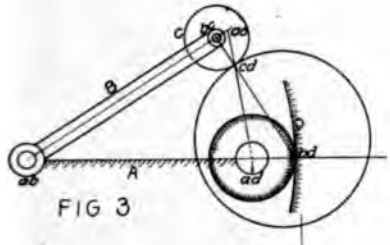


FIG 3

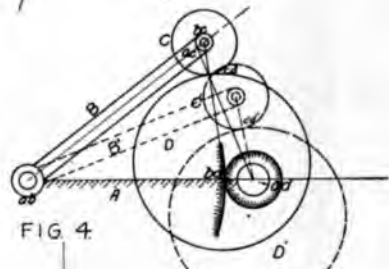


FIG 4

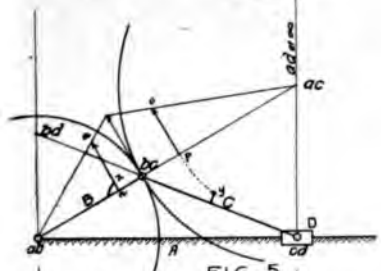


FIG 5

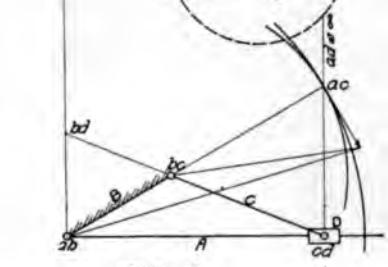


FIG 6

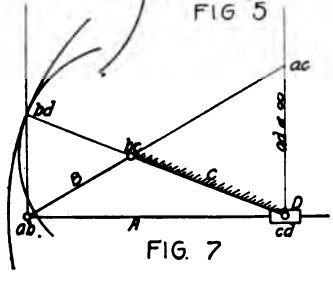


FIG 7

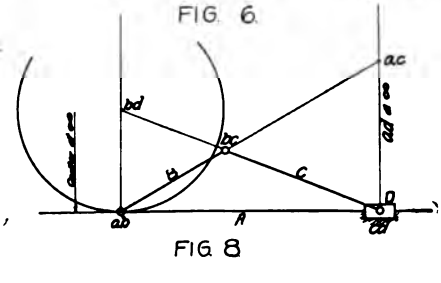


FIG 8

from the velocity of the given point the velocity of the common point, then the velocity of the required point from that of the common point." This rule enables us to omit from consideration all intermediate links in the more complex mechanisms, as will be shown later. In Fig. 3, the rocker arm B and cam D move with respect to each other. At this position of the mechanism

$$\frac{V°B}{V°D}=\frac{bd-ad}{bd-ab}$$

when A is stationary. In Fig. 4, the same equation holds, the difference being that here the directional motion of the two links is opposite, whereas in Fig. 3 it is the same. The relative directional rotation is very clear after noting the position of the common point with respect to the centros of rotation. In this position of the mechanism, the two centrodes vary in opposite direction when motion occurs. The dotted position indicates where the directional motion is changing from one to another hence B has a zero angular velocity for the instant.

Figures 5, 6, 7 and 8 represent the slides crank chain with various links held stationary and with comparisons made of angular and linear velocities.

In Fig. 5, A is stationary.

$$\frac{V°B}{V°C} \text{ as } \frac{bc-ae}{bc-ab}$$

The linear velocity of point

$$y=\frac{on}{mn}\times \text{velocity of } x,$$

the velocities being compared through that of the common point. The centrode of B has a constant diameter, while the centrode of C varies.

In Fig. 6 B is stationary.

$$\frac{V°C}{V°A}=\frac{ac-ab}{ac-bc}$$

Here the two centrodes vary together, the distance between centers being a constant.

In Fig. 7, C is stationary.

$$\frac{V°D}{V°B}=\frac{bd-bc}{bd-dc}$$

This case is usually a troublesome one to students but here involves no complexity. Both centrodes vary together as in Fig. 6.

In Fig. 8, D is held stationary.

$$\frac{V°B}{V°A}=\frac{ab-ad}{ab-bd}=\infty$$

that is the V°B is infinitely greater than that of A, as we have here a small centrode rolling up one of infinite radius. Here the small centrode though it changes in diameter proves that B is always infinitely greater in angular velocity than is A.

Thus far no really complex case has been taken up, but the application of the method will be shown to be as simple as in any of those already given.

Take the complex eight link mechanism, the Peaucellier Cell. Each link moves with respect to every other one. Usually link A is stationary, but it might be desirable to compare the V° of C to that of E when F is held stationary. From what has gone before we have

$$\frac{V°C}{V°E}=\frac{ce-ef}{ce-cf}$$

C and E are therefore rotating in the same direction with respect to F about cf and ef respectively.

Let point *n* be any extended point in link E, and with a known velocity, what will be the velocity of point *m* in link C when F is held stationary?

It may be found by determining from the given velocity of *n*, the velocity of the point common to the two moving links, *ce*, and from this, the velocity of *m*, by means of the triangles of velocities.

Take the three links B, D and H, well separated, and let B be stationary. Then

$$\frac{V°D}{V°H}=\frac{dh-bh}{dh-bd}$$

Here again *dh* (named from the two moving links D and H,) is the point of contact of the two links or centrodes, and the points *bh* and *bd* are respectively the centers of rotation of links H and D with respect to B. The directional rotation of H and D are opposite—a point not readily seen by imagining the links moving about B.

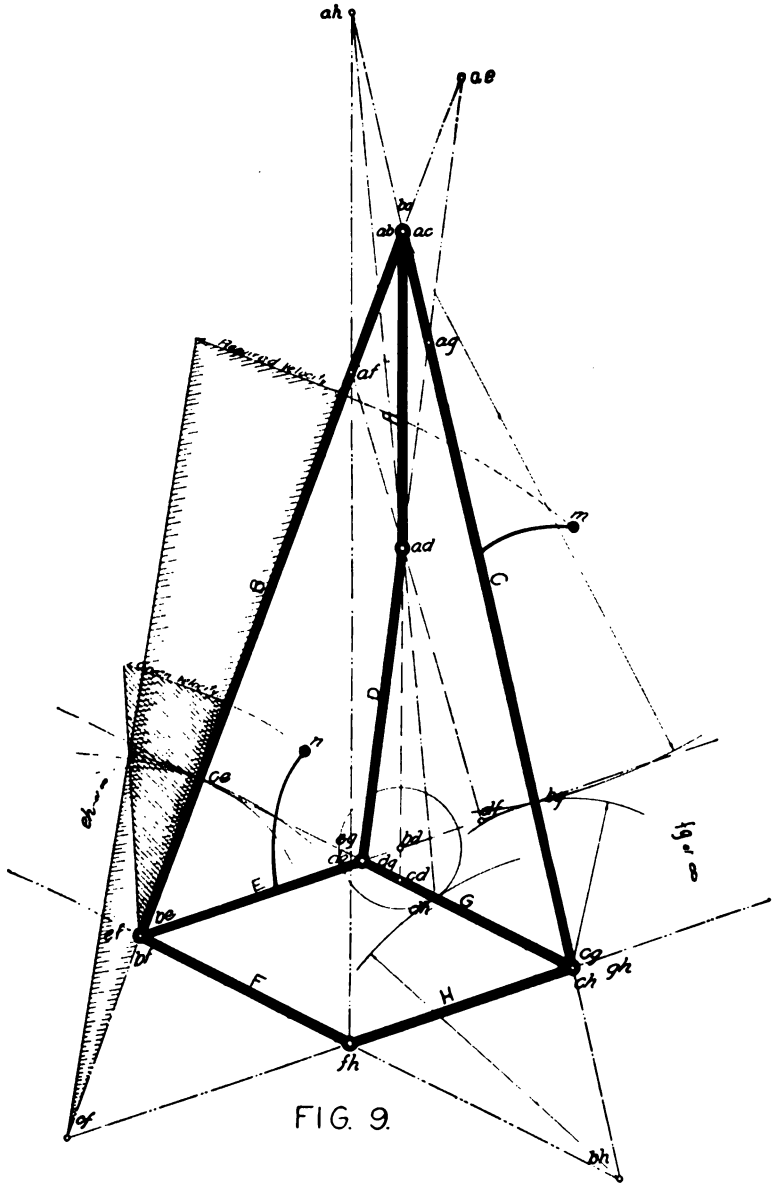


FIG. 9.

Take the three links B, G and C. Let C be stationary, then we have

$$\frac{V^{\circ}B}{V^{\circ}G}=\frac{bg-cg}{bg-bc}$$

the two links B and G have opposite directional rotation with respect to the stationary link C.

When considering

$$\frac{V^{\circ}E}{V^{\circ}H}$$

when A is held stationary we have

$$\frac{V^{\circ}E}{V^{\circ}H}=\frac{eh-ah}{eh-ae}$$

the four points *ah* and *ae* at the top of the plate are the centers of the rotation and the common point of the two links is at ∞ hence the angular velocities of E and H with respect to A show themselves to be equal.

In conclusion then, we employ here a more simple set of centrodes; we have a rapid graphical solution in which a direct method of comparing angular and linear velocities is involved, a method where directional rotation is made less intricate, where the relative value of instant angular and linear velocities can be represented by a simple equation and where solutions of a complex nature are brought down to a plane with those less complex.

University of Wisconsin, December, 1903.

A NEW ARRENURUS AND NOTES ON COLLECTIONS MADE IN 1903.

RUTH MARSHALL.

During the summer and fall of 1903, dredgings were made in several new places in the state for Arrenuri; the results have been disappointing in the number of individuals found, but two species having been added to the list reported a year ago (Trans. of Wis. Acad. of Sciences, Arts and Letters, 1903, Vol. XIV, Part I, p. 145–172, Pl. XIV–XVIII). One of these species appears to be new; both are here described. Only Arrenuri belonging to the subgenus *Megalurus* Thon were studied. Most of the collections were made in July and August in Washburn County. This region is richly supplied with small lakes and ponds, most of them seemingly of glacial origin. All but one of those visited are shallow, and have more or less extensive zones of marsh. The season was unusually cool, and during the latter part of the summer there were heavy rains. The bodies of water having similar features in southern and eastern Wisconsin have rarely failed, when examined, to yield Arrenuri. But in most cases none were found in these northern waters.

A large number of collections were made in the shallows bordering the islands in Lake Spooner. Here were found, in small numbers, *A. globator* Müll., *A. megalurus* Mar., and *A. manubriator* Mar. In Peaslee's Pond, a small pool on shore, were found *A. globator* Müll. and several individuals of the species *A. Birgei* Mar., whose color was rusty red instead of the usual blue green. The same species were found in Mud Creek, the outlet of Lake Spooner, a spring-fed stream, the lower end of which is choked with water plants. Here also was found, for the first time, *A. caudatus* (de Geer). On a trip about twelve miles to the northeast from Lake Spooner to the Little McKinzie River, collections were made in three small

ponds: Tadpole Pond, near the village of the same name; a smaller pond two miles west; and Morrison's Pond. All seemed particularly well suited for water-mites; but none were found excepting in Morrison's Pond, and there only three individuals.

Shell Lake, which is very deep, gave no mites at all. One specimen, *A. Birgei,* was found in Rice Lake, Barron County, a lake which has been made partly artificial by the erection of a dam. None were found in a small mill-pond in the village of St. Croix Falls, St. Croix County. In late August *A. globator* Müll. and *A. megalurus* Mar. were found in Mirror Lake, Sauk County. A collection was made in September in the mill-pond at Whitewater; and another at Tustin, on Lake Poygan, west of Oshkosh. In both were found *A. globator, A. megalurus,* and *A. Birgei* in small numbers.

Arrenurus caudatus (de Geer).

Plate XL, Figs. 1a—1c.

1879. *Arrenurus caudatus* Neuman, Om Sveriges Hydr., Sv. Handlingar, Bd. 17, Nv. 3, S. 85, tab. XII, Fig. 2.
1882. *Arrenurus caudatus* Haller, Die Hydrachniden der Schweiz, S. 43.
1887. *Arrenurus caudatus* Barrois et Moniez, Catalogue des Hydrachnides, S. 24.
1892. *Arrenurus caudatus* Piersig, Eine neue Hydrachnidengattung aus dem säch. Erzgebirge, Zool. Anz. Nr. 405, S. 420.
1892. *Arrenurus caudatus* Kramer, Die Tier- und Pflanzenwelt des Süsswassers, Bd. II, S. 24, Fig. 2 b.
1893. *Arrenurus caudatus* Koenike, Hydrachnologische Berichtigungen, Zool. Anz. Nr. 410, S. 20.
1893. *Arrenurus caudatus* Piersig, Beiträge zur Hydrachnidenkunde, Zool. Anz. Nr. 431, S. 398.
1893. *Arrenurus caudatus* Koenike, Weitere Anmerkungen zu Piersigs Beiträgen zur Hydrachnidenkunden, Zool. Anz. Nr. 435, S. 463.
1894. *Arrenurus caudatus* Piersig, Ueber Hydrachniden, Zool. Anz. Nr. 443, S. 109.
1895. *Arrenurus caudatus* Kramer, Ueber Benennung einiger Arrenurus-Arten, Zool. Anz. Nr. 465, S. 1–5.

1895. *Arrenurus caudatus* Koenike, Nordamericanische Hydrachniden, Abhandlung des naturwissenschaftlichen Vereins zu Bremen, Bd. 13, S. 184.

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1896. *Arrenurus caudatus* Pisarovic, Zur Kenntnis der Hydrachniden Böhmens, Sitzungsbericht, etc., S. 3.

1897. *Arrenurus caudatus* Piersig, Deut. Hydrachniden, Heft 22, Lfg. IV, S. 285–288, Fig. 74.

1899. *Arrenurus caudatus* Thor, Tredie Bidrag til Kundskaben om Norges Hydrach., S. 24, Pl. IX, Fig. 88.

1901. *Arrenurus caudatus* Piersig, Das Tierreich, 13 Lieferung. Hydrach. und Halacaridae, S. 87–88.

1902–3. *Arrenurus caudatus* Soar, A Few Words on Freshwater Mites, Trans. of the Edinburgh Field Naturalists' and Microscopical Society.

This species, described so often by European hydrachnologists, has been found but once by the writer, although many collections have been made during the past ten years in various parts of Wisconsin and elsewhere. But a single individual was found; this was in Mud Creek, the inlet of Lake Spooner, near Spooner, Wis., on July 1st, 1903. It was at once recognized by its bright colors and its general conformity to the detailed figures of Piersig and Koenike. The area near the end of the body and the anterior part of the appendage was deep blue; there were brownish blue bands on the front part of the body, while the remaining areas were pale orange, and the legs bluish green. The entire length was 1.26 mm.; the greatest width, which is in the middle of the body, is 0.7 mm. It is readily distinguished from other Arrenuri of the sub-genus Megalurus by the shape of the appendage. This is constricted at the base, broadest in the middle where there is a slight hump, and narrowed at the end. Here it is slightly indented; on either side of the incision are two slight scallops, on this specimen not as pronounced as in Piersig's and Koenike's figures. In the last third are some peculiar structures. There is a small, somewhat heart-shaped, bluntly pointed elevation (H^1); posterior to it is a pair of low rounded humps (H^2), between which is a de-

pression. There are a number of hairs on this part of the appendage, as shown by the figures. In general these structures agree with those of Koenike's detailed figures. The body is moderately elevated inside the dorsal line, though not as much so as Piersig shows. The dorsal line runs over on the appendage and is unclosed. The genital areas form scarcely perceptible rolls on the dorsal side. At their ends are four hairs on each side. The epimera are of the usual form, and the legs present no striking peculiarities distinct from other Arrenurus males.

Through the kindness of Dr. C. F. George, identified specimens of *A. caudatus* from England were obtained for comparison. The Wisconsin form was found to differ from these in the same details that it differed from the descriptions of the German hydrachnologists. From the same source were received also specimens of *A. globator* Müll., *A. cylindratus* Piers., and *A. securiformis* Pier. (= *A. festivus* Koen.). Here again, in several details of structure, they did not agree with the forms already identified by the author (1903). However, the differences have not seemed great enough, without further comparison with European forms, to justify the formation of four new species.

Arrenurus Morrisoni nov. spec.

Plate XL, Figs. 2a—2d.

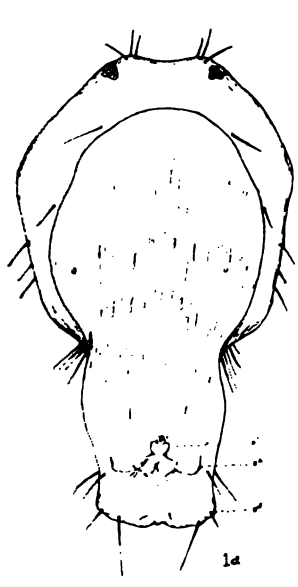
This new species is represented in the author's collection by only one individual. It was found July 30, 1903, in Morrison's Pond, near the Little McKinzie River in Washburn County, Wisconsin. This pond is perhaps one-fourth of a mile long, and nearly filled up with water-lilies and other plants. Collections were made at various points; but *A. Morrisoni* and *A. Birgei* Mar., with one female unidentified, were the only Arrenuri found, and of these but a single individual each. The new form was not examined until after it had been a few days in Koenike's preserving fluid; it had then a pale yellowish hue, probably not differing much from the color in the fresh specimen. It measured 1.23 mm. in length and 0.68 mm. in width. Its most striking feature is the appendage which is nearly two-thirds as long as the body. It is rather low, moderately constricted at the base; then it rounds out considerably

and has a slight dorsal rounded hump, becoming rapidly constricted at the end to half the width at the base. The end is richly supplied with hairs and has some peculiar structures. It may best be described as consisting of two terraces, both with scalloped corners (H^1, H^2). Between the humps forming the rounded corners of the upper is a depression, from the depth of which rises a small elevation (A). Between the side humps of the lower terrace, in the depression, is a little point (B). The middle depressed part extends out a little beyond the corners. The form of the body is rather peculiar, being broadest anteriorally, in the region of the second pair of epimera; there are no humps or small elevations, and the anterior border is bowed out strongly. The area inside the dorsal line has about the same elevation as the rest of the body. The whole dorsal side is moderately arched, and much higher than the appendage. The epimera have the usual form, the fourth being broadest. The genital areas are unusually large, oval in shape, and form conspicuous rolls projecting out beyond the body wall. The fourth leg is like that of other males of this group of Arrenuri; the third, fourth and fifth joints being richly provided with swimming hairs, and the fourth bearing the usual short process. The fourth segment of the palpus is longest, and has a sickle-shaped bristle; the fifth is small and forked, and the second has one or more stout barbed bristles.

PLATE XL.

EXPLANATION OF PLATE.

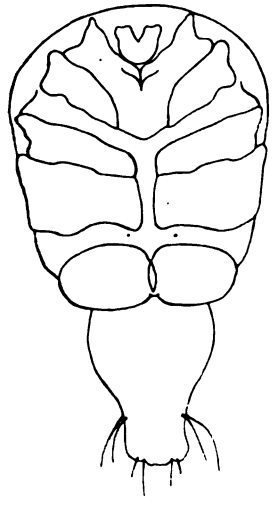
1a, *Arrenurus caudatus* (de Geer), dorsal view.
b, *Arrenurus caudatus* (de Geer), ventral view.
c, *Arrenurus caudatus*, (de Geer), lateral view.
2a, *Arrenurus Morrisoni* nov. spec., ventral view.
b, *Arrenurus Morrisoni* nov. spec., lateral view.
c, *Arrenurus Morrisoni* nov. spec., dorsal view of the appendage.
d, *Arrenurus Morrisoni* nov. spec., palpus.



1a

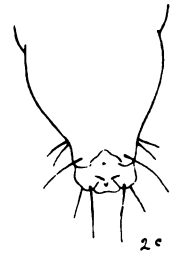
1b

1c



2a

2d



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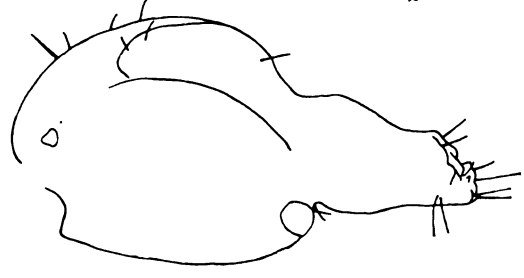

2b

THE STRUCTURE OF THE STARCH GRAIN.

R. H. DENNISTON,

Instructor in Pharmaceutical Botany, University of Wisconsin.

It has been pointed out by Nägeli and others that the peripheral part of certain varieties of starch shows a somewhat different reaction to stains than the central portions. The large eccentric grains from the rhizome of Canna, for example, when treated with the safranin, gentian voilet, orange triple stain, show, besides the light and dark violet layers making up the body of the grain, an outer layer which is fairly uniform in width and which takes the orange stain.

There are but few data in the literature on the differential staining of the various portions of starch grains, but this does not seem so remarkable when we consider that the more exact methods of fixing and staining technique are of comparatively recent introduction.

In 1847, Nägeli (1) published an article on the structure of the starch grain in which he held that there is an outer layer of the starch grain which is composed of cellulose, or the substance of which cell membranes consist. This view was soon disproved, however, by Von Mohl (2) who showed that the test used by Nägeli to distinguish starch from cellulose was unreliable.

Crüger (3) found a layer between the protoplasm and the starch grain, which "did not stain blue with iodine, nor did it stain brown so rapidly as the surrounding protoplasm." As he makes no mention of the plastid, this is probably what he saw and his figures bear out this view.

In 1885, Mikosch (4) thought he found evidence of the existence of an intermediate region between the grain and the plastid which is filled with what he called a "mother substance for the grain."

Meyer (5) states that normal starch grains do not possess a

specially differentiated outer layer, but that he found such a layer in a few cases, in starch from the tuber of a potato.

Such a layer is described by Salter (6) who believed that it is composed of starch, but that it is much more dense than the remainder of the grain, hence its different staining qualities.

I have taken up the study of this outer differentiated layer with special reference to the question of its chemical nature and its relation to the growth of the starch grain.

I have studied material from the rhizome of Canna, tuber of potato, leaves and stems of *Pellionia Daveauana,* grains of corn, wheat, barley, rye and sugar-cane, seeds of bean and pea.

A number of fixatives were tried but Flemming's weaker and stronger chrom-osmic-acetic acid mixture gave the best results.

The staining was done in all cases where other stains are not mentioned, by the safranin, gentian violet, orange and triple stain method.

If one examines sections stained by this method, containing hundreds of starch grains large and small, the striking fact is noticed that the mass of each grain is a bright violet, the strata being respectively lighter or darker, while around the violet mass and inside the leucoplast, a sharply defined orange layer is apparent.

In order to determine in how far the staining reactions were due to different lengths of exposure to the individual stains, a series of slides was prepared. In all cases they were exposed to safranin for five minutes; after washing in water, six slides were exposed to a saturated solution of gentian violet for five minutes each, then treated with orange for the following different lengths of time: one minute, five minutes, ten minutes, twenty minutes, sixty minutes, three hours. These preparations will be referred to by fractions, the numerator representing the time of exposure to violet in minutes and the denominator the time of exposure to orange.

In 5/1 the body of the grain is made up of deeply stained violet layers. The outer layer is also violet but very pale in color. The leucoplasts do not appear on all grains, but when visible are grayish in color.

In 5/5 the body of the grain is again stained dark violet but an orange layer at the outside is plainly marked and extends entirely around the violet portion, beneath the leucoplast. This is the pale violet layer of the 5/1 preparation.

In 5/10 the staining is essentially as in the latter case with the exception that here we often get the orange layer divided by a dark line. This line, in some cases, extends entirely around the grain, in others it is seen on the posterior end and part way down the sides.

In 5/20 the violet has been removed to greater extent in some of the layers in the body of the grain than in others. Certain broad bands seem to be not at all affected by the orange. In some grains, two dark blue layers exist as separate broad bands in the body of the grain; these apparently run out into the orange layer where they continue as separate dark lines around the hilum.

5/60 and 5/100 show no changes which can be referred to a longer exposure to orange. The layers of the inside of the grain are stained a pale blue in these preparations. Those immediately surrounding the hilum are white.

In 5/180 it was found that only a few layers still hold any violet stains. These are situated midway between the hilum and the posterior end of the grain.

It is seen by this series of slides that we may stain the whole grain orange in some cases where the time of exposure to this stain has been of sufficient duration, but that by applying the stains, each for an approximately equal length of time, we get but a single layer of orange and that surrounding the violet portions of the grain. The difference in appearance of the two portions of the grain, the dark violet stained body and the surrounding orange layer, is so striking and clearly marked that it seems improbable that it is due simply to lack of penetration of the orange. When once the grain is stained violet, a long exposure to orange is necessary to remove the violet from any of the grain but the layer in question, while but a few minutes suffice to remove all traces of violet from this layer and replace it by orange. A short exposure to the violet stain will often leave this outer layer perfectly colorless, while the inner parts are stained deep violet. These differences in staining properties would seem to indicate that certain differences either of a chemical or physical nature exist between the body of the starch grain and the outer layer.

A single section from the rhizome of Canna will often show all the stages in growth of the starch grains. Frequently the

small grains are found as small round orange colored bodies, and are always surrounded at this stage by a large leucoplast.

Certain of these young grains show no signs of lamination, others no larger in size show one or two pale violet circles toward the center but no violet layers. Still other grains show a pale violet region at the center around the dark violet hilum. Grains in the same region and slightly larger show a central region stained dark violet, surrounded by a pale violet layer and this, surrounded by an orange layer. Preparations of this kind show that the violet layers at the center are the first to be formed.

As an eccentric grain grows the plastid becomes stretched and the mass of it remains at one end of the grain. It is beneath this mass of the leucoplast that the broader portions of the eccentric layers are deposited. The orange layer is usually of fairly uniform width around the grain. In some cases where the orange layer was not found, the grains showed evidences of solution on the outside.

The starch of a number of other plants was examined and with similar staining the orange layer found to be present. In barley and wheat the starch grains are concentric and in both we find an orange layer at the outside. In the leaves and stems of *Pellonia Daveauana* large eccentric starch grains are present which show the orange staining layer beneath the chloroplast. In starch from *Dieffenbachia Seguina, Phajus grandifolius Oxalis viola* and *Dicentra cucullaria,* orange staining outer layers are found.

This constancy of the orange layer, occurring as it does, from the very young to the very old grains, seems to point to the fact that we have in the starch grain two substances, differing in their properties, one staining violet and the other orange. One striking fact noted was that while the outer orange staining layer completely surrounded the grain, the violet layer next to it runs only part way around. If the outer layer is simply denser starch, as is claimed by Salter, it is difficult to account for the formation of eccentric layers of starch inside the so-called dense layer.

The following experiment gives strong evidence that the violet stain passes through the orange layer readily but is not absorbed by it. In microtome sections, the staining of a large eccentric Canna grain may be watched under the microscope

THE DIURNAL MOVEMENT OF PLANKTON CRUSTACEA.

CHANCEY JUDAY.

INTRODUCTION.

The following paper on the diurnal movement of plankton crustacea is based upon observations made for the Wisconsin Geological and Natural History Survey between July 1, 1900 and June 30, 1901. The work was planned to continue for a longer period but it became necessary to discontinue it at the end of a year. This left the work in a rather unsatisfactory condition for it had scarcely passed the experimental stage. As a result, this report is preliminary in nature but it is written with the hope that it may contain helpful suggestions for future work along this line.

Enough, however, was accomplished during the year to show that diurnal movement is not a simple, unchangeable phenomenon which may be determined for the various crustacean forms of a lake by a single set of observations. On the contrary, the results show not only that the movement of a single species is not the same in all the lakes in which it is found but also that the movement of a species may change from time to time in the same lake. To determine the extent and nature of these changes, it would be necessary to make regular observations on a lake covering the period from early spring till late fall. Such a study would contribute much, no doubt, to a better understanding of the factors instrumental in the production and modification of diurnal movement.

I wish to acknowledge my indebtedness to Dr. E. A. Birge, Director of the Survey, for the plan of the work, as well as for his direction and helpful counsel during its progress.

possible that the substance first formed from starch by the action of diastase is the same that is present in the orange layer in the formation of the grain. As an hypothesis it may be suggested that a viscid mother substance, as Mikosch believed, which becomes more and more concentrated by additions from without, until layers of starch are laid down on its inner surface. In the young grains starch is deposited equally all round, but soon the grain by its growth stretches the plastid, and the granular substance inside is too viscid to allow the additions from the thicker part, to spread readily to the mother substance at the opposite end of the grain, under the thinner part of the plastid. In this manner the mother substance under the thicker part of the plastid, soon becomes saturated and it is on this side that the thick portions of the starch layers are deposited. This assumption is in harmony with the fact that when the eccentric layers begin to form they are simply thinner on the anterior end, then they become incomplete and finally are laid down on the posterior end only.

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by allowing a dilute solution of gentian violet to run under the cover. The layers inside this outer layer begin to absorb the stain at once but the outer layer is not at all affected. The violet stain passes through the outer layer without being absorbed. Of the layers inside, some are stained a deep violet, others take up only a small amount of stain and appear pale violet in color.

Starch grains artificially corroded by diastase were also studied to learn if possible which part of the grain, the violet or the orange layers, would be affected more readily.

In starch grains which have been treated with diastase for a number of days, characteristic corrosion figures appear. Large eccentric Canna grains corroded in this manner show the outer orange layer still intact except for one or two small areas usually at the posterior end. The outer violet layers have been dissolved in a number of places, but remain fairly intact. Considerable substance has been removed from the interior of the grain, and other parts remaining in the center are stained orange.

In some cases the center of the grain has been completely dissolved and there is only a shell remaining made up of parts of the outer violet layers.

In the case of barley grains when corroded in this manner, the solution takes place in interrupted concentric circles, certain layers appear to be more easily dissolved by the diastase than others. Here, also, the center of the grain seems to be most susceptible to diastase action. No orange material is present outside the violet layers in these corroded grains, but the parts remaining in the center take the orange stain.

It is noticeable that in a corroded grain the portions of the layers bordering upon corrosion channels show a margin of orange stained material, which blends gradually into the violet of the unaffected portions.

In many cases in starch grains the outer orange layer is divided into a number of separate layers. These are rarely uniform either in extent or staining qualities. The inner layers grow thinner as they pass towards and around the hilum. Where there are several orange staining layers, the inner ones invariably show a trace of violet, although predominantly orange in color. This would seem to indicate that the orange staining material surrounding the grain passes gradually and

not suddenly into the inner layers. The orange layers are of fairly uniform width around the grain, being slightly wider on the posterior end, while the outermost violet layers are incomplete, that is, are broad curved bands on the posterior end of the grain, but extend but a short distance down the sides of the grain towards the hilum, and in only a few instances were seen to pass entirely around it. This makes it evident that the orange layer does not pass over *in toto* into the violet. Still even in such cases of transition it is difficult to say to what the change is due by which the orange pass into the violet staining layers. It may be due to a condensation of the carbohydrate material, brought about by the abstraction of water, or to a more deeply seated chemical change.

It is possible that this orange staining substance is carbohydrate material which has been brought inside the leucoplast but which has not yet fully taken on the nature of starch and the capacity to fix the violet stain. This would seem to be more natural than the assumption that starch can show such a variable reaction to the same stains.

In the development of the cell plate in the onion root-tip, the equatorial zone was found by Timberlake (7) to become filled with a substance that stains strongly with the orange of the triple stain. This substance appeared to be entirely homogeneous and with ruthenium red or iron haematoxylin appeared colorless while the cell wall was stained.

Timberlake says, "The similarity of this substance to that of the cell wall, together with its presence in the region of the spindle in which the cell wall appears later, I have taken to signify the presence of a carbohydrate substance destined for the formation of the new cell wall."

We have thus two cases in which a transition substance in the formation of solid carbohydrates appears, taking the orange stain. In both cases it is formative in nature, the one passing over into the cellulose wall, the other forming starch.

We find the very young starch grains either staining entirely or showing a large proportion of orange. We find an outer layer of orange in the older grains, and by following the course of development of the starch grain, we are led to believe that the orange staining substance in young and old grains is identical. We also find that the action of diastase causes a larger proportion of the grain to take the orange stain. It is further

LOCATION OF THE LAKES.

Observations were made on thirty of the lakes of southeastern Wisconsin. Twenty-five of these lakes lie in two groups, fifteen belong to The Chain o' Lakes in Waupaca County and ten belong to the Oconomowoc–Waukesha lakes in Waukesha County. The five lakes not included in these two groups are Mendota, Geneva, Green, Big Cedar, and Elkhart. Only ten of these thirty lakes, however, were studied with special reference to diurnal movement: Beasley and Rainbow of The Chain o' Lakes, Okauchee, Oconomowoc, Nagawicka, and Pewaukee of the Oconomowoc–Waukesha lakes; and all the individual lakes named above except Elkhart.

The physical features of these lakes have been fully discussed by Fenneman (5) in Bulletin No. 8 of the Wisconsin Geological and Natural History Survey, so that little need be said here on that point. Suffice it to say that these ten lakes represent various physical, as well as biological conditions. They differ widely in area, the largest lake having over seven hundred times the area of the smallest. The maximum depth ranges from a little less than fourteen meters in Pewaukee lake to seventy-two meters in Green lake, but it is less than thirty meters in seven of the ten lakes.

There was also a very marked difference in the amount of aquatic vegetation found in the lakes.

APPARATUS AND METHODS.

The pump method was used in making the catches. A number three clock pump and garden hose with a diameter of two and a half centimeters, were used. A quantity of water, ten to fifteen liters, was pumped from each depth and strained through a plankton net whose straining cone was made of Dufour's No. 20 bolting cloth. During the process of straining, the net was submerged so that the stream of water from the pump would not strike the bolting cloth directly.

A complete set of observations consisted of four series: a day, an evening, a night, and a morning series. These were made during clear weather, with the exception of one day series, and at a time when the surface water was disturbed as little as possible by waves. The day and night catches were made at intervals of one to three meters and they covered the

entire depth of each lake with the exception of Green lake. The day catches were made not earlier than three hours after sunrise and, with one exception, not later than three hours before sunset; the night catches, two to three hours after sunset.

The evening and morning catches extended to a depth of two to eight meters. They were made at half hour intervals and usually covered the period from about half an hour before sunset to two hours after sunset. Some observations, however, were begun as early as an hour and a half before sunset. The morning series were begun an hour and a half to three hours before sunrise and continued until sunrise, or sometimes an hour after sunrise. The purpose of these observations was to determine approximately the time at which the various forms showing diurnal movement, reached the surface in the evening and left it in the morning.

The depth of all the surface catches varied from about three centimeters, when the water was calm, to seven or eight centimeters when it was disturbed by waves.

The time was too limited to permit a count of the smaller forms for nearly nine hundred catches were made during the year. So each catch was examined under the low power of a microscope and the relative number of individuals of each of the smaller forms was indicated by the five terms, absent, rare, few, many, or abundant. The larger forms were counted. The results for each form in the day catches and in the night catches were then tabulated in parallel columns so that the depth to which diurnal movement affected the day distribution could be determined readily. In making these comparisons, however, one must constantly remember the fact that two catches from the same depth and separated by only a brief interval of time, may show a considerable difference in the number of crustaceans. Therefore, unless the difference between a day catch and a night catch at the same depth was great enough to exclude all doubt, it was counted as no change. But at and near the surface, there was little danger of a mistake, especially in those forms which were absent from this region in the day time but occupied it at night.

Separate but similar tabulations were made for the evening and morning catches. Some of the genera represented, such as Diaptomus and Cyclops, were tabulated as a whole and not separated into species.

In stating the time at which the various forms reached the surface in the evening and left it in the morning, the exact hour of the day is not given. The time is reckoned in half hours with respect to the time of sunset and sunrise. This is done because the time of the movement is closely related to the time of sunset and sunrise and this latter time is constantly changing with respect to the hours of the day.

The following results are given in considerable detail for each lake in order to indicate whatever change there may be in the movement of any form at different times in the same lake. Then the results are given for each form for all the lakes in which it is found, so as to show the differences in the movement of the same form in different lakes.

BEASLEY LAKE.

The observations on this lake consisted of a day and a night series the last of July and a complete set of observations early in September, 1900. The lake was comparatively poor in phytoplankton.

Daphnia hyalina.—In July, young were found at the surface during the day and adults at a depth of one meter. In the night catch made an hour and three quarters after sunset, adults were very numerous at the surface, apparently indicating the presence of a "swarm."

In September, the day position of both young and adults was the same as in July. Adults appeared at the surface during the second half hour after sunset and disappeared about half an hour before sunrise.

Diaptomus.—In July, both young and adults were absent from the upper four meters in the daytime but both were found at the surface an hour and three-quarters after sunset.

Only adults were found in September. They were at a depth of one meter during the day. They appeared at the surface during the first half hour after sunset and were not found in the surface catch made nearly two hours before sunrise.

Cyclops.—This form did not show any diurnal movement either in July or September.

Nauplii.—There was no diurnal movement of the nauplii.

Corethra larvae.—In the day catches of July they were not found above a depth of eight meters but were found at a depth

of only four meters at night. In September, their day and night positions were practically the same.

RAINBOW LAKE.

A day, a night, and an early morning series were made late in July and a complete set of observations early in September, 1900. Comparatively little phytoplankton was found on both occasions.

Daphnia hyalina.—Two varieties of this form were found. One variety had round helmets and the other had rather long, pointed helmets. The former remained in the region of the thermocline both day and night in July and also in September.

Young of the variety having pointed helmets were found at the surface in the day catches of July and adults at a depth of two meters. The latter were present in the surface catch made two and a half hours after sunset.

In September, young were not found in the upper four meters and adults not in the upper six meters in the day catches. Both appeared at the surface during the second half hour after sunset and both left the surface about one hour before sunrise.

Daphnia retrocurva.—Adults were absent from the upper two meters in the daytime in July but were present in the surface catch at night. They were at a depth of six meters in the daytime in September. They came to the surface a little more than an hour after sunset and were not found at the surface two hours before sunrise. Young were not noted in either month.

Ceriodaphnia.—This form was rare both in July and September but showed no diurnal movement.

Diaphanosoma brachyurum.—Young and adults were not found above a depth of five meters in the day catches of July but both were at the surface at night. In September, young were at the surface and adults at a depth of two meters in the day catches. The latter appeared at the surface during the first half hour after sunset and disappeared again during the second half hour before sunrise.

Leptodora hyalina.—In July, this form was not found in the upper nine meters in the daytime but was taken at a depth of only one meter at night. The September day and night positions were six and four meters respectively.

Bosmina.—This form was rare and no diurnal movement was apparent.

Holopedium gibberum.—In July, this species was found in the region of the thermocline but there was no movement. It was not found in September.

Epischura lacustris.—In July, this form was at a depth of two meters in the day catches but was present in the surface catch at night. It was not above four meters in the daytime in September but appeared at the surface near the end of the first half hour after sunset and was not found in the surface catch made an hour and a half before sunrise.

Diaptomus.—Young were at the surface and adults at a depth of one meter in the day catches of July. The latter came to the surface at night. In September, adults were at a depth of two meters in the daytime. They reached the surface during the first half hour after sunset and left the surface again during the second half hour before sunrise.

Cyclops, nauplii, and *Corethra* larvae.—No diurnal movement was shown by these forms in either month.

BIG CEDAR LAKE.

The observation on this lake consisted of a day and a night series made on August 1, 1900.

Daphnia hyalina.—This form was not found in the upper three meters in the day catches but it was present in the surface catch at night.

Ceriodaphnia.—This form was rare and showed no diurnal movement.

Diaphanosoma brachyurum.—The day and night positions of this species were the same.

Bosmina.—This form was rare and showed no diurnal movement.

Epischura lacustris.—This species was found at a depth of four meters in the day time but it was present in the surface catch at night.

Diaptomus.—Both young and adults of this form were found at a depth of four meters in the day time but both came to the surface at night.

Cyclops.—The young of this genus were found at the surface in the day catches but the adults were at a depth of four meters. The latter came to the surface at night.

OKAUCHEE LAKE.

A complete set of observations was made on this lake in August, 1900, a day and a night series in October, and a complete set in June, 1901. The phytoplankton was rather abundant.

Daphnia hyalina.—Two varieties of this form were found in August and October, those with round and those with pointed helmets. Only the round helmeted ones occurred in June.

Young of the round helmeted variety were found at the surface and adults at a depth of two meters in the day catches of August. The latter appeared at the surface during the second half hour after sunset and disappeared during the second half hour before sunrise. Young were at the surface in October and adults at a depth of one meter. The latter were present in the surface catch at night. In June, both young and adults were at a depth of one meter in the daytime. The former reached the surface about half an hour before sunset and the latter about sunset. Both disappeared from the surface about sunrise.

The variety with pointed helmets did not show diurnal movement.

Daphnia retrocurva.—This species was found in August and October but not in June. There was no diurnal movement.

Daphnia pulicaria.—In August, young were found at a depth of eight meters and adults at nine meters in the daytime. Two and a quarter hours after sunset young were found at a depth of only two meters and adults four meters.

In October, young were at a depth of six and adults twelve meters in the daytime. Three and a quarter hours after sunset the former were at the surface and the latter at two meters. In June, the day catches showed young at a depth of one meter and adults at three meters. The former appeared at the surface about half an hour before sunset and the latter about two hours after sunset. Both disappeared from the surface during the fifth half hour before sunrise.

Daphnia longiremis.—This species remained in the region below the thermocline or below twelve meters, both day and night during these observations. It was most abundant within two or three meters of the bottom. About the middle of November, however, after the disappearance of the thermocline, it was found at a depth of only two meters on a cloudy day.

Ceriodaphnia.—This form was rare and did not show diurnal movement.

Diaphanosoma brachyurum.—This species did not show diurnal movement in August and only a slight change in October. It was not found in June.

Leptodora hyalina.—In August, young were found at the surface in the daytime and adults at a depth of nine meters. The latter appeared at the surface during the second half hour after sunset and left the surface during the second half hour before sunrise. No definite movement was observed in October.

Both young and adults were found at a depth of seven meters in the daytime in June. The former appeared at the surface during the first half hour after sunset and adults about an hour later. Both left the surface during the third half hour before sunrise.

Bosmina.—*Bosmina* was at a depth of one meter in the daytime in August. It appeared at the surface during the second half hour after sunset but did not leave the surface until after sunrise. No diurnal movement was observed in October and June.

Chydorus.—This form was not found in August. It was rare in October and common in June but it did not show diurnal movement on either occasion.

Epischura lacustris.—This species was not found in any of the day catches in August. It appeared at the surface, however, during the second half hour after sunset and disappeared again during the second half hour before sunrise. It was not found in October. In June, it was not present in any of the day catches but it appeared at the surface during the second half hour after sunset and disappeared during the second half hour before sunrise.

Diaptomus, Cyclops, and *nauplii* did not show diurnal movement.

Corethra larvae.—Larval *Corethra* showed no diurnal movement in August. It was not found above a depth of twenty meters in any of the day catches in October but it was found at a depth of only one meter at night. Only one individual was observed in all the catches made in June.

OCONOMOWOC LAKE.

A complete set of observations was made on this lake in August, 1900, a day and a night series in October, and a complete set in June, 1901. The lake was poor in phytoplankton.

Daphnia hyalina.—In August, young of this species were rare in the upper five meters in the daytime and adults were at a depth of seven meters. The former appeared at the surface during the second half hour after sunset and adults half an hour later. No adults were at the surface an hour and a half before sunrise and the young left the surface during the second half hour before sunrise. Only young were found in the October catches. They were at a depth of five meters in the daytime but were found at the surface two hours after sunset.

In June, only adults were found. They were at a depth of two meters in the daytime but came to the surface about an hour and a half after sunset and were not found in the surface catch made two and a half hours before sunrise.

Daphnia pulicaria.—Young were at a depth of six meters and adults ten meters in the day catches of August. The former came to the surface about half an hour after sunset and adults half an hour later. Neither young nor adults were found in the surface catch made an hour and a half before sunrise. Adults only were found in October. They were at a depth of twelve meters in the daytime but were taken in a surface catch made two hours after sunset.

In June, both young and adults were found at a depth of only one meter in the daytime. The former came to the surface during the first half hour after sunset and adults half an hour later. Both left the surface during the second half hour before sunrise.

Diaphanosoma brachyurum.—There was no diurnal movement of this form.

Leptodora hyalina.—Only the young of this species were found in August. They were not present in the surface catch made two hours after sunset but were in some of the morning surface catches. They left the surface during the second half hour before sunrise. *Leptodora* was not found in June.

Bosmina.—There was no diurnal movement of *Bosmina.*

Chydorus.—This form was not found in August and October. In June, it was rare but showed no diurnal movement.

Epischura lacustris.—This species was not taken in the day catches in August but it appeared at the surface during the first half hour after sunset and disappeared during the second half hour before sunrise. It was not found in October.

In June, it was found at the surface only in the morning catches and it disappeared during the second half hour before sunrise.

Diaptomus.—In August, young were at the surface and adults at a depth of two meters in the daytime. The latter appeared at the surface about sunset and left the surface again about sunrise. There was no diurnal movement in October and June.

Cyclops and *nauplii.*—There was no diurnal movement of these forms.

Corethra larvae.—In August, *Corethra* larvae were not found in the upper eight meters in the daytime but were at five meters in the night catches. In October, they were at a depth of fourteen meters in the daytime but were at three meters at night. Only one individual was found in all the catches made in June.

NAGAWICKA LAKE.

Two complete sets of observations were made on this lake, one in August, 1900 and another in June, 1901. Phytoplankton was rather abundant.

Daphnia hyalina.—Two varieties of this species were present. Those with round and those with pointed helmets were found in August but only the former in June. In August, the young of the round helmeted variety were at a depth of six meters and adults at three meters in the daytime. The former appeared at the surface about sunset and adults during the second half hour after sunset. No adults were found at the surface one and a half hours before sunrise and the young left the surface during the third half hour before sunrise.

In June, young were at the surface and adults at one meter in the daytime. The latter appeared at the surface during the second half hour before sunset and disappeared again about sunrise.

Young with pointed helmets were at the surface and adults at one meter in the daytime in August. The latter came to the surface during the first half hour after sunset and were not

found in the surface catch made an hour and a half before sunrise.

Ceriodaphnia.—This form was rare and showed no diurnal movement.

Diaphanosoma brachyurum.—In August, both young and adults were at a depth of one meter in the daytime. The former appeared at the surface more than half an hour before sunset and adults during the first half hour after sunset. Both were absent from the surface catch made an hour and a half before sunrise. *Diaphanosoma* was not found in June.

Leptodora hyalina.—Young and adults were at a depth of five meters in the day catches of August. Both appeared at the surface during the first half hour after sunset. Adults left the surface during the third half hour before sunrise and young half an hour later.

Neither young nor adults were found in the day catches in June. The former appeared at the surface during the first half hour after sunset and adults half an hour later. Adults left the surface during the second half hour before sunrise and young not until the second half hour after sunrise.

Bosmina.—In the day catches of August, this form was at a depth of one meter. It appeared at the surface during the second half hour before sunset and did not leave the surface until later than the first half hour after sunrise.

In June, it was found at a depth of four meters in the daytime. It came to the surface during the second half hour before sunset and was still present half an hour after sunrise.

Chydorus.—This form was present only in the catches made in June. No diurnal movement was noted.

Epischura lacustris.—This species was not found in August and only one individual was found in the June catches. It was in a surface catch made one hour after sunset.

Diaptomus.—Young were at the surface in the day catches in August and adults at one meter. The latter came to the surface during the first half hour after sunset and disappeared again during the second half hour before sunrise. There was no movement in June.

Cyclops and *nauplii.*—There was no movement of these forms.

Corethra larvae.—In August, they were not found above seven meters in the day catches. They came to the surface

during the third half hour after sunset and were not present in a surface catch made an hour and a half before sunrise. They were not found in June.

PEWAUKEE LAKE.

This lake is the shallowest of the ten on which observations were made for diurnal movement. The eastern half of the lake scarcely exceeds two meters in depth. This part was originally a swamp and the water is maintained at its present depth by means of a dam about two meters high at the outlet. The whole of the eastern half supported a dense growth of the larger forms of aquatic plants and the entire lake was the richest of the ten in phytoplankton.

The observations were made in the western half of the lake which has a maximum depth of thirteen meters. They consisted of a single day and a single night series.

Daphnia hyalina.—There was no diurnal movement of this species.

Ceriodaphnia.—This form showed no movement.

Diaphanosoma brachyurum.—This species was at a depth of one meter in the day catches but was present in the surface catch at night.

Diaptomus.—In the daytime, this form was at a depth of one meter but it came to the surface at night.

Cyclops.—The young of this form were at the surface and adults at a depth of one meter in the day catches. The latter came to the surface at night.

Nauplii.—There was no diurnal movement of the nauplii.

LAKE GENEVA.

A complete set of observations was made in August, 1900. This lake was comparatively poor in phytoplankton.

Daphnia hyalina.—Both young and adults were absent from the upper five meters in the day catches. The former reached the surface during the second half hour after sunset and adults half an hour later. Both left the surface about one hour before sunrise.

Diaphanosoma brachyurum. Neither young nor adults were found above five meters in the day catches but both came to the

surface during the fourth half hour after sunset. No adults were present in the surface catch made an hour and a half before sunrise while the young disappeared during the second half hour before sunrise.

Leptodora hyalina.—Only three young of this form were found in all the catches, so no definite movement could be determined.

Epischura lacustris.—This form was not found above a depth of ten meters in the day catches. It appeared at the surface during the second half hour after sunset and disappeared again during the third half hour before sunrise.

Limnocalanus macrurus.—Only one individual of this species was found and this was in the surface catch of the night series.

Diaptomus.—Young were at a depth of three meters and adults five meters in the daytime. Both reached the surface during the first half hour after sunset. The adults left the surface during the second half hour before sunrise and the young half an hour later.

Cyclops.—Young were at a depth of three and adults eight meters in the daytime. The former appeared at the surface shortly before sunset and adults had not reached the surface two and a half hours after sunset. The latter, however, were found in some of the surface catches made in the morning. They left the surface during the second half hour before sunrise and the young not until after sunrise.

Nauplii.—There was no diurnal movement of the nauplii.

GREEN LAKE.

A complete set of observations was made on this lake in September, 1900. The day series was made while the sun was partly obscured by clouds. The lake was poor in phytoplankton.

Daphnia retrocurva.—The young of this species were at a depth of six meters and adults ten meters in the daytime. The former appeared at the surface during the first half hour before sunset and the latter during the second half hour after sunset. A surface catch made one and a half hours before sunrise contained neither young nor adults.

Diaphanosoma brachyurum.—This form was not found in the upper four meters in the daytime. It appeared at the sur-

face during the first half hour after sunset and left again during the second half hour before sunrise.

Leptodora hyalina.—This species was at a depth of six meters in the day catches. It came to the surface during the first half hour after sunset but left the surface earlier than one and a half hours before sunrise.

Bosmina.—This form was at a depth of one meter in the day series but came to the surface shortly before sunset. It was not present in the surface catch made as early as one and a half hours before sunrise.

Epischura lacustris.—This species was not found above a depth of twelve meters in the day catches. It reached the surface during the first half hour after sunset and left again earlier than an hour and a half before sunrise.

Limnocalanus macrurus.—Only one individual of this form was found above a depth of fifty meters in the day catches. In the night series, ten were present in the catch made at fifteen meters and others were found in the catches made between fifteen and fifty meters. No individuals were found in any of the night catches made above the thermocline, that is, above fifteen meters.

Diaptomus.—The young of this form were found at the surface in the daytime and adults at a depth of four meters. The latter appeared at the surface shortly before sunset and disappeared during the first half hour after sunrise.

Cyclops.—Young were at a depth of two meters and adults eight meters in the day series. The former reached the surface shortly before sunset and the latter during the third half hour after sunset. Both left the surface about sunrise.

Nauplii.—There was no diurnal movement of the nauplii.

Marsh also (9a, p. 217) noted diurnal migrations of *Daphnia retrocurva, Diaphanosoma, Diaptomus, Epischura,* and *Limnocalanus* in Green lake.

LAKE MENDOTA.

The observations on lake Mendota were made during the month of October, 1900 and between April 24 and June 27, 1901. Over three hundred catches were made during these two periods.

Daphnia hyalina.—In October, young were found at the surface in the daytime except for a brief period in the middle of

bright, sunny days. During the first half of the month, adults were at a depth of three-fourths to one meter in the daytime. On the 5th, they came to the surface during the first half hour after sunset but, on the 8th, they were found in the surface catch made half an hour before sunset. On the 12th, they left the surface during the second half hour before sunrise. In the day series of the 25th, adults were at a depth of only a quarter of a meter and they had not yet appeared at the surface three and a quarter hours after sunset.

In 1901, diurnal movement was noted as early as April 24, only twelve days after the disappearance of the ice. At this time the water had a temperature of 7.2° C. at the surface and 4.8° at the bottom, eighteen meters. April 24, 25, 29 and May 3, young were rare and there was practically no difference between day and night conditions. On these dates, adults were found at a depth of one meter in the day catches but they came to the surface at night. In the day catches of May 15, young were at a depth of one meter and adults half a meter deeper. Both appeared at the surface about sunset. The adults left the surface about an hour before sunrise and young were still present one hour after sunrise. On May 28, young were at the surface and adults at a depth of one meter in the daytime. The latter came to the surface at night.

In June, young *D. hyalina* were found at a depth of half a meter in two day series. They were found at the surface at the beginning of each of the three evening series and one of these was begun as early as three hours before sunset. In the morning catches they were at the surface as late as an hour and a half after sunrise. In the two day series, adults were at a depth of one meter. In two evening series, they came to the surface nearly an hour before sunset and not until the second half hour after sunset in the third series. In the two morning series, adults left the surface during the first half hour after sunrise.

Daphnia retrocurva.—This species was found in October and June but no diurnal movement was noted. It was found at a greater depth, however, in the daytime than *Daphnia hyalina*, the same as noted by Birge (2b, p. 402).

Daphnia pulicaria.—There was no movement of this species.

Ceriodaphnia.—This form was rare and showed no movement.

Diaphanosoma brachyurum.—There was no diurnal movement of this species.

Leptodora hyalina.—This species was found in October, May, and June. It was found in only one of the six day series of these three months and that was October 25, in the catch made at a depth of six meters. Birge (2b, p. 405) found the movement of this form to be less than three meters in extent.

In October, young came to the surface during the first half hour after sunset on the 5th and adults half an hour later. Young appeared at the surface during the second half hour before sunset on the 8th and adults during the first half hour after sunset. In the morning series of the 12th, adults left the surface during the third half hour before sunrise and young were still present in the surface catch made just at sunrise.

In May, *Leptodora* came to the surface during the fourth half hour after sunset in an evening series and left the surface during the third half hour before sunrise in a morning series. It was not found in the other evening and morning observations.

In June, adults appeared at the surface about half an hour after sunset on the 3rd and young had not yet appeared half an hour later. On the 11th, young came to the surface about an hour after sunset and adults had not yet appeared as late as an hour and a half after sunset. In the morning series of the 12th, neither young nor adults were found as early as two and a half hours before sunrise. Adults came to the surface during the third half hour after sunset on the 24th but no young were found as late as an hour and a half after sunset. In the morning catches of the 25th, adults left the surface during the second half hour before sunrise and young about sunrise.

Bosmina.—This form was found in June but there was no diurnal movement.

Chydorus.—There was no movement of this form.

Epischura lacustris.—*Epischura* was not found in any of the day catches but was present in the evening, night, and morning catches of October and June. In October, it appeared at the surface about half an hour after sunset on the 8th. On the 12th, it left the surface about two hours before sunrise. In June, this species came to the surface during the second half hour after sunset in both of the evening series. In the morn-

ing series of the 12th, it left the surface during the first half hour before sunrise and, on the 25th, half an hour earlier.

Diaptomus.—There was no diurnal movement of this form in October and April. In May, both young and adults showed a movement of half a meter on the 3rd and also on the 15th. On the latter date, young came to the surface about sunset and adults half an hour later. On the 17th, adults left the surface during the second half hour before sunrise and young were still present in the surface catch made one hour after sunrise. On the 28th there was no movement of either young or adults, as both were found at the surface in the daytime. In June, young were found at the surface in the daytime and adults at a depth of a quarter of a meter. The latter came to the surface an hour or more before sunset. On one occasion, they did not leave the surface until the second half hour after sunrise and, at another time, they were still found in the surface catch made an hour and a half after sunrise.

Cyclops.—This form was regularly found at the surface in the daytime and there was comparatively little increase in number at night.

Nauplii.—There was no diurnal movement of the nauplii.

The above results show that the upper meter of Lake Mendota is well populated in the daytime and that the movement, therefore, is confined within very narrow limits. In this respect, they are in complete agreement with the results obtained by Birge (2b). With the exception of *Corethra* larvae which were not found in my observations, the following statements of his results apply equally well to mine:

1. "On calm sunny days, the upper ten centimeters of the lake may be almost devoid of crustacea. At a depth of half a meter, however, the numbers become considerable and may be very great."

2. "The population of the upper meter is largely composed of immature crustacea, the percentage of young varying in different species."

3. "A far larger proportion of *Cyclops* is usually obtained from the upper five or ten centimeters than comes from any of the other forms of limnetic crustacea and it may be present at the very surface on hot, calm, sunny days."

4. "In windy and cloudy weather, the crustacea approach nearer the surface, the numbers of *Diaptomus* and *Cyclops* be-

ing especially increased by the change in the condition of the sky. *Daphnia hyalina* also may come nearer the surface."

5. "At night, the population of the upper meter changes in character. The young, instead of being concentrated in swarms in this layer, become more evenly distributed and the adults, which were found below the one-meter level, rise toward the surface. *Leptodora* and larval *Corethra* have been regularly taken at the surface in considerable numbers at night. During the day, these animals are rarely, if ever, found close to the surface, although they may be abundant enough above the three-meter line. It would appear, therefore, that these animals move toward the surface at night, together with the crustacea on which they feed. *Epischura* seems to have the same habit." (Birge 2b. pp. 407–410.)

MOVEMENTS OF THE DIFFERENT FORMS OF CRUSTACEA.

Daphnia hyalina Leydig.

This species was found in nine of the ten lakes. Two varieties of individuals, those with round and those with pointed helmets, were found in three lakes. There was a diurnal movement of the adults in eight of the nine lakes, ranging in extent from a quarter of a meter to seven meters. With one exception, the young did not show so great a movement as the adults for they were nearer the surface in the daytime. Where the extent of migration of the adults did not exceed a meter, young were usually found at the surface in the daytime, and in some cases they were at the surface when the adults showed a movement of two meters.

This is a very small movement as compared with that observed by Burckhardt (4) for this species in Vierwaldstättersee, a lake which is deeper than any of these nine Wisconsin lakes. He found diurnal movements of twenty to thirty meters in March, while a maximum of fifty meters was noted.

The variety having round helmets did not show diurnal movement in Rainbow lake while that with pointed helmets did. The reverse of this was true in Okauchee lake and there was a movement of both varieties in Nagawicka lake.

In the eight lakes in which there was movement, the time of arrival at the surface varied from the third half hour before

sunset to the third half hour after sunset. In Lake Mendota alone, the time of reaching the surface changed from the second half hour after sunset to the second half hour before sunset in a single month, June, 1901. The time of leaving the surface in the morning varied from more than two and a half hours before sunrise to the first half hour after sunrise. Where there was a diurnal movement of the young, they generally came to the surface earlier in the evening and remained later in the morning than the adults.

Daphnia retrocurva Forbes.

This species was found in four lakes and there was diurnal movement in two, Rainbow and Green lakes. In the former, there was a movement of two meters in July and six meters in September. In the latter, the young showed a movement of six and adults ten meters.

In Rainbow lake, adults came to the surface a little more than an hour after sunset and were not present in the surface catch made two hours before sunrise. In Green lake, adults came to the surface during the second half hour after sunset and were not found in the surface catch made an hour and a half before sunrise.

Daphnia pulex De G. var. *pulicaria* Forbes.

There was a movement of this form in two of the three lakes in which it occurred. In Oconomowoc lake, the movement of the adults varied in extent from twelve meters in October to one meter in June and in Okauchee lake, for the same months, from ten to three meters. The young showed a movement ranging in extent from one meter to six meters. This variation in the extent of the movement was undoubtedly due to the change in the temperature of the water. *D. pulicaria* preferred to remain in cool water in the daytime so, when the upper stratum of water became too warm, it moved down to a greater depth. Thus the deserted zone near the surface gradually grew in thickness as the water became warmer. After the formation of the thermocline, it occupied the lower part of this stratum and the region below and moved downward as the thermocline worked downward. For instance, the thermocline

was two meters deeper in October than in August in Oconomowoc lake and it was found that the day position of *D. pulicaria* was two meters deeper. The same results were obtained in Okauchee lake with the exception that both were three meters deeper in October than in August. About the middle of June, it was found much nearer the surface because only a comparatively thin stratum of water had become too warm for it. Also Birge (2b, p. 401) found that the center of population for this form in Lake Mendota rose from fourteen meters in late September to four meters in the first part of November, while in the latter part of December it lay only about two meters below the surface. He also states that a reversal of this diagram "would serve fairly well to indicate the downward migration of the species in the spring." There was no diurnal movement of *D. pulicaria* in Lake Mendota but the above serves to show how temperature would have affected the extent of such a daily migration if there had been one.

In coming to the surface in Oconomowoc lake in August, this form moved up into the water that was at least 15° C. warmer than that occupied by it during the daytime. In October, the difference in temperature did not exceed 7° or 8°. In Okauchee lake, the difference in temperature was not so great in August as in Oconomowoc lake but it was about the same in October.

In Oconomowoc lake, adult *D. pulicaria* appeared at the surface during the second half hour after sunset and then disappeared during the second half hour before sunrise. In Okauchee lake, they were not found at the surface in August and October, but in June they came to the surface about two hours after sunset and left again during the fifth half hour before sunrise. In both lakes, the young preceded the adults in the evening by a half hour to two hours. In one instance, the young left the surface about the same time in the morning as the adults and again at least an hour later than the adults.

Daphnia longiremis Sars.

This species was found in only one lake, Okauchee. There was no diurnal movement.

vidual was found in the night catches above this region. On the contrary, the only individual found in Lake Geneva was taken in a surface catch at night.

Diaptomus.

This genus was represented in each of the ten lakes. Diurnal movement was noted in seven, ranging in extent from a quarter of a meter to five meters. The time of arrival of the adults at the surface in the evening varied between the extremes of an hour before sunset and half an hour after sunset. In the morning, they left the surface as early as two hours before sunrise in one case, while in another they remained as late as an hour and a half after sunrise.

Cyclops.

Representatives of this genus were found in all the lakes. Diurnal movement was observed in four, ranging in extent from one meter to eight meters.

Morning and evening catches were made in two of the four lakes in which there was a movement of *Cyclops*. In one lake, adults came to the surface during the third half hour after sunset and in the other they had not appeared as late as two and a half hours after sunset. In one case, they left the surface during the second half hour before sunrise and in the other about sunrise.

Nauplii.

Nauplii were present in all the lakes. They showed no diurnal movement.

Corethra larvae.

Corethra larvae were found in six lakes. There was a movement of them in five lakes ranging in extent from two to nineteen meters.

WHAT DIURNAL MOVEMENT IS.

In a previous paper (8b, p. 128), the statement is made that diurnal movement does not mean that the various forms congregate at the surface at night in swarms. This is shown by

the fact that the species exhibiting this phenomenon in its most typical form are found in as great abundance at a depth of a meter or two, or even deeper, as at the surface. In fact these forms are usually more abundant some distance below the surface than at the surface. It means that some forms desert the upper strata of water during the day but move up into these strata at night. In other words, they spread out into this region which is deserted by them during the day, for there is no general upward migration of the whole body of crustacea. With rare exceptions, some individuals of each form continue their ascent until they reach the surface. Under this phenomenon we also include instances where the crustacea are found in very limited numbers near the surface in the daytime but occupy this region in much greater abundance at night.

EXTENT OF DIURNAL MOVEMENT.

The foregoing results show a wide range in the extent of these daily migrations. The variation is no greater, however, than one should expect from the great diversity of the ecological factors involved. Each lake possesses factors peculiar to itself and the crustacea respond to these differences in environment in a greater or lesser degree. As a result, the diurnal movement in each lake has certain individual characteristics. Thus in the various lakes, the zone deserted by *Daphnia hyalina* during the day varies in thickness from a quarter of a meter to seven meters while there was no movement at all in one lake. Also the changes in the environment of a single lake during the seasons in which diurnal movements occur, may affect the extent of these migrations very materially. That is, there may be a seasonal variation in the extent of this movement. To mention only two instances, the movement of *Daphnia pulicaria* changed from twelve meters in October to one meter in June in Oconomowoc lake and that of *D. hyalina* increased from two meters in July to six meters in September in Rainbow lake.

The various forms of crustacea are not equally sensitive to the factors instrumental in the production of this phenomenon for they do not all show migrations of equal extent in the same lake. For example, in Okauchee lake *Daphnia hyalina* showed a movement of two, *D. pulicaria* five, and *Leptodora* nine

meters in August while in June the migrations were one, three, and seven meters respectively. With few exceptions, the young were nearer the surface in the daytime than the adults and as a result their migrations were not so great. In fact, young were frequently found at the surface in the daytime in cases where the movement of the adults did not exceed a meter or two. Burckhardt (4) also found that adult *Daphnia hyalina* moved down about five meters deeper in the daytime than the young. In cases where there was a migration of both young and adults, the former usually reached the surface earlier in the evening and remained later in the morning than the adults.

Marsh (9b, p. 381) says, "Most of the movement is within one meter of the surface, the most marked changes being within one-half meter of the surface and below three meters the amount of movement is very slight." In only three of the ten lakes were the migrations confined within these narrow limits. In the other seven, they varied in extent from two to twelve meters and in these cases, of course, the changes extended below three meters. The movement of any species, however, rarely affected the day vertical distribution in a noticeable degree more than three or four meters below the upper limit of adults in the daytime.

The greatest movement shown by any species was the apparent movement of thirty-five meters of *Limnocalanus*. While there is some doubt as to the exact extent of the movement of this form, it could easily make such extensive migrations because it is a very good swimmer. *Daphnia hyalina* showed a maximum movement of seven meters; *D. retrocurva*, ten meters; *D. pulicaria*, twelve meters; *Diaphanosoma brachyurum*, five meters; *Leptodora hyalina*, nine meters; *Bosmina*, four meters; *Epischura lacustris*, twelve meters; *Diaptomus*, five meters; *Cyclops*, ten meters.

HORIZONTAL MIGRATION.

In several instances there were evidences of a considerable horizontal migration of some of the littoral crustacea. Such forms as *Gammarus, Alona,* and *Cypris* were taken in surface catches at night in the limnetic region where the water was eighteen meters or more in depth. That is, they were found at the regular stations for observations at night but never in the

daytime. The horizontal migration of *Cypris* was also noted by the author in Winona lake (8b, p. 127).

TIME OF MAXIMUM NUMBER AT THE SURFACE.

Blanc (3) found the crustacea most abundant at the surface at 4 a. m. in lac Léman. Fordyce (6) obtained the same result for *Leydigia fimbriata*. Fuhrman (7) states that in his observations the crustacea reached a maximum at the surface shortly before sunrise. As none of my observations extended through the entire night, it is impossible to say at what time the maximum number was present at the surface. However, some of the morning observations were made early enough to show that the maximum period was not as late as 4 a. m., especially during the months of June, July, and August. In many instances, the Daphnias, *Leptodora* and *Epischura* disappeared entirely from the surface before this hour and when they were present so late as this, they were found to be fewer in number than an hour or two earlier. In general, the crustacea were not so abundant in the morning catches, and some of them were made as early as 2 a. m., as in the evening catches, especially those made from one to two hours after sunset. These facts go to show that the maximum period probably came in the early part of the night rather than toward morning. Such a condition would be in harmony with the results obtained for Winona lake (8b, p. 128) where most of the crustacea were found in greatest abundance at the surface from 7:30 to 8 p. m. in August.

ORDER OF REACHING THE SURFACE AND LEAVING IT.

The order in which the crustacea appeared at the surface in the evening varied somewhat but in general the Copepoda preceded the Cladocera. This agrees with Blanc's (3) observations. *Cyclops* seemed to be affected least by the factors that are responsible for this movement. It was found in all ten of the lakes but there were daily migrations in only four. Evening catches in two of these four lakes, however, show that *Cyclops* ranked about the same as *Daphnia hyalina* in the order of reaching the surface. The following three are named in the order of their appearance, *Diaptomus, Daphnia hyalina,* and *D. pulicaria*. *Diaphanosoma* ranked about the same as *Diap-*

tomus and *Epischura* about the same as *D. hyalina*. The order of leaving the surface in the morning was substantially the reverse of the order of appearance in the evening.

ECOLOGICAL FACTORS INVOLVED.

Diurnal movement has been attributed to several causes. Food, temperature, and light have probably been cited most frequently. Each has been supported more or less strongly as being the chief cause of the phenomenon because of the different results obtained by various plankton observers. It has been considered a food phenomenon because the phytoplankton has been found most abundant near the surface, thus making this a good region for food. As a result the crustacea move up into this region so that they may obtain an abundance of food. In general it may be said that these results do not support this idea. For example, some forms moved up from depths where food was nearly, if not quite as abundant as at the surface. In several instances, crustaceans rose from regions where the greater part of a catch was made up of phytoplankton and this phytoplankton consisted of the same plant forms as found at the surface.

Then, too, some crustacea were able to obtain a sufficient amount of food at considerable depths to enable them to remain at these depths both day and night, while other forms nearer the surface, and thus in a region more plentifully supplied with food, moved up regularly at night. In Okauchee lake *Daphnia longiremis* remained below twelve meters both day and night from August to October while other crustacea much nearer the surface, hence in a region where food was more plentiful, came to the surface at night. Also in Lake Mendota, *D. pulicaria* remained in the region of the thermocline both day and night where food was not nearly so abundant as near the surface while other forms near the surface moved up at night. Fuhrman (7) states that it could not be considered a food phenomenon in the lake on which he made observations because phytoplankton was scarce at the surface.

Considering the phenomenon from the standpoint of temperature Ostwald (9) has given a very interesting theory to account for it. He believes that the descent is due to the lowering of the viscosity or the internal friction of the water (die innere

Reibung des Wassers) through its increase in temperature. This lowering of the internal friction of the water through its increase in temperature, affects the speed of sinking of the plankton and thereby calls forth a descent of the pelagic forms during the early hours of the day. An increase of the internal friction by cooling will not, however, cause a movement toward the surface. Diffusion streams and active wandering bring about the ascent during the second half of the night, toward morning. The active wandering varies according to the swimming ability of the different forms. My observations do not lend support to this theory. The forms showing diurnal movement came to the surface early in the evening instead of toward morning. In fact, they came to the surface so early in the evening that the water had cooled comparatively little so that the internal friction at this time was near its minimum for the day. In the morning, also, many crustacea left the surface an hour or two before sunrise. This means that they descended during a period while the water was still cooling and therefore while the internal friction was increasing instead of decreasing. With very few exceptions, the migrating crustacea left the surface in the morning before the sun had affected the temperature of the water in the least. Therefore temperature can not be regarded as either a direct or an indirect cause of the diurnal movement noted in these observations. As stated above, however, temperature did affect the extent of these daily migrations in a very marked degree in some instances. Waldvogel (14) states that in the two lakes on which he made observations the crustacea ceased their diurnal movements during the strongest warming of the water in August and did not resume them again until the water had cooled below 20° C. In this instance temperature acted as an inhibitory factor rather than as a cause of migration. Burckhardt (4) says also that temperature is not the cause of the phenomenon because he observed diurnal migrations in January during a snow storm and at this time the water of the lake was practically of a uniform temperature. Parker (11) found that the migration of *Labidocera aestiva* did not depend primarily on temperature.

A number of observers have attributed the diurnal movement of crustacea to light. That is, the forms showing this phenomenon are negatively phototropic and therefore move down

from the upper stratum of water on the approach of day in order to avoid the intense light. The weight of evidence in these observations favors this explanation. The results show pretty conclusively that light is the primary factor in causing the descent of the crustacea in the morning and in keeping them from the surface during the day. It is more difficult to state, however, just why they move upward so promptly when the intensity of the light is sufficiently decreased.

The importance of light is shown by the fact that the time at which the upward movement takes place in the evening and the time of the downward movement in the morning are related more or less closely to the time of sunset and of sunrise. Some crustacea also were found nearer the surface on cloudy than on clear days. In some instances forms which were absent from the upper stratum of water on clear days were found there on cloudy days in nearly as great abundance as at night. This was also found to be true of the Daphnias in Winona lake (8b). In this connection, Birge (2b, p. 426) describes a set of observations on Lake Mendota made on a day when there was an alternation of cloud and sun. During the sunny periods, the Daphnias were at a depth of one meter and during the cloudy periods one-half meter. He says, "It was as though the Daphnias were depressed by a force against which they were contending, and they rose with the promptness of a compressed spring relieved of weight." Burckhardt (4) also found that the poor zone of *Daphnia hyalina* increased directly proportional to the strength of the daylight. In my results, the limnetic crustacea fall into two groups with respect to the effect of sun and cloud on their vertical distribution in the daytime in the upper stratum. *Daphnia hyalina* and *D. retrocurva* were nearer the surface on cloudy than on clear days. Also the distribution of *Diaptomus* and *Cyclops* in the upper stratum was affected by the obscuring of the sun by clouds, for they frequently occupied this region in nearly as great numbers on cloudy days as at night. The day position of *Daphnia pulicaria*, *Leptodora*, and *Epischura*, however, was the same on cloudy as on clear days. This seems to show that light is a more important factor in producing diurnal movements in the former group than in the latter, or perhaps it is better to say that the influence of light is modified by other factors not so much in the former as in the latter group.

It is evident that the effect of light is modified more or less by other factors. It has been noted above that temperature affected the depth migration of *Daphnia pulicaria* very materially, changing it from twelve meters in October to one meter in June. In three lakes, temperature apparently affected the extent of the movement of *D. hyalina* as it moved down deeper in the daytime as the water grew warmer so that the difference in temperature at the lower limit of the deserted stratum did not exceed 2° C., while the change in temperature at the surface was very much greater. In Rainbow lake, for example, the depth of the migration of this form changed from two meters in July to six meters in September. This increase was not due to the fact that the water was more transparent because the transparency was practically the same on both occasions. These conditions agree with Birge's statement (2b, p. 426) that a high temperature increases the negative action of light and a low temperature lessens or reverses it. In three other lakes, however, temperature did not affect the extent of the migration of *D. hyalina*. In Okauchee lake, for example, it was found at a depth of one meter in the day catches of August, October, and June and the temperature at this depth was 27°, 15°, and 21° respectively.

The quantity of phytoplankton in a lake affects diurnal movement. Fuhrman (7) says that, where phytoplankton is abundant at the surface, it forms a veil or covering which absorbs very much light. Under cover of this, the organisms may come close to the surface without being exposed to direct sunlight. With two exceptions, my observations show that the crustacea remained closer to the surface in the daytime in those lakes which were rich in phytoplankton than in those which were poor in phytoplankton. As a result, the movement was not so great in the former class of lakes as in the latter. It seems probable that the various substances dissolved in the water exert an influence on diurnal movement. These substances affect the amount of light absorbed by the water and also modify, in a slight degree at least, the character of the light transmitted.

If diurnal movement were purely a light phenomenon, there ought to be a direct relation between the transparency of the water and the depth to which the crustacea descend in the daytime. Burckhardt (4) found that this was true for *Daphnia hyalina* in Vierwaldstättersee. My results show no such rela-

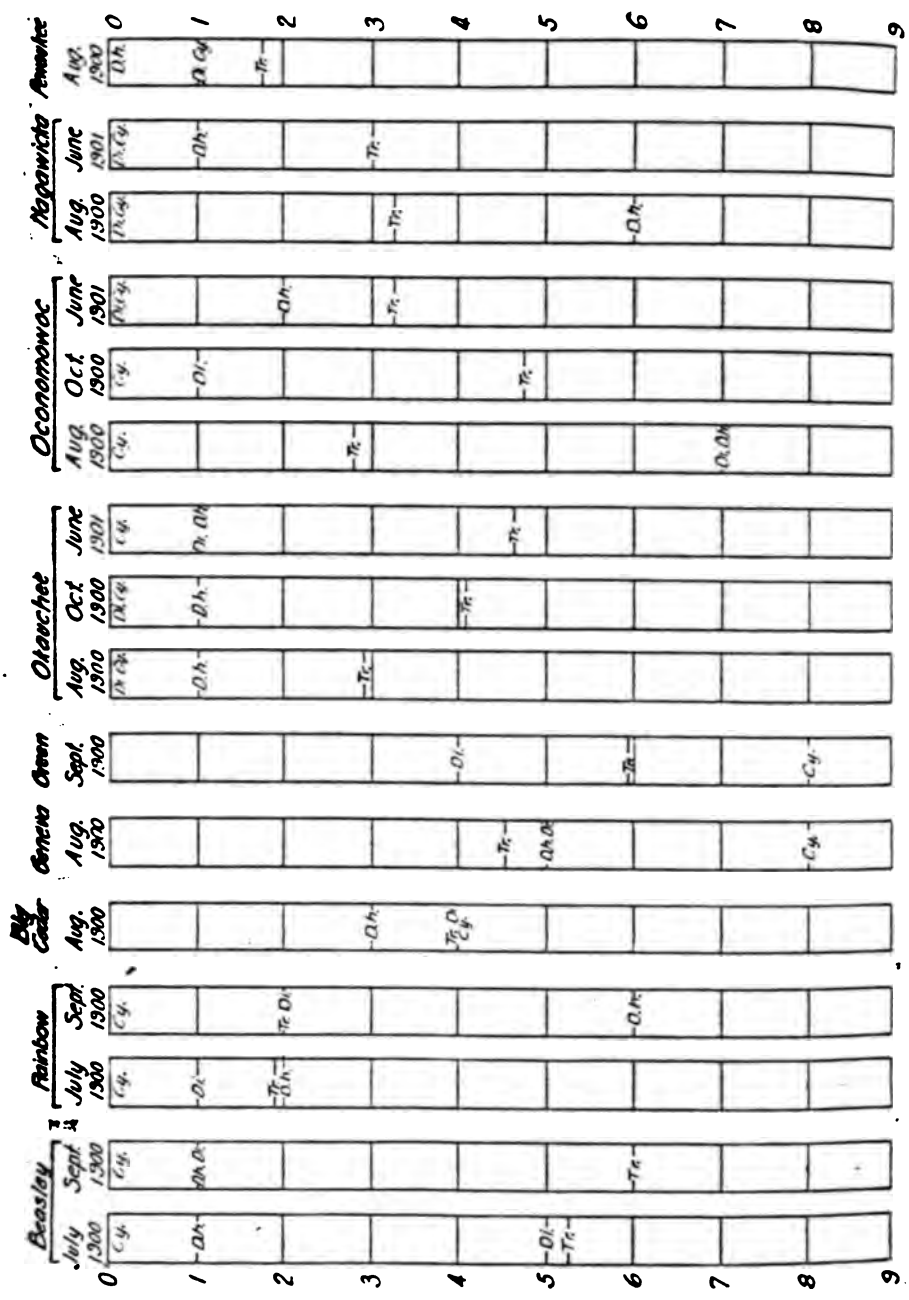

FIG. 1.—Vertical distribution of crustacea in Wisconsin Lakes. For explanation see text, p. 603

tion, however, for any of the migrating forms. The accompanying diagrams, Figures 1 and 2, bear upon this point. The transparency of the water was determined by means of a Secchi's disk and the line marked Tr., representing transparency, shows the depth at which the disk just disappeared from

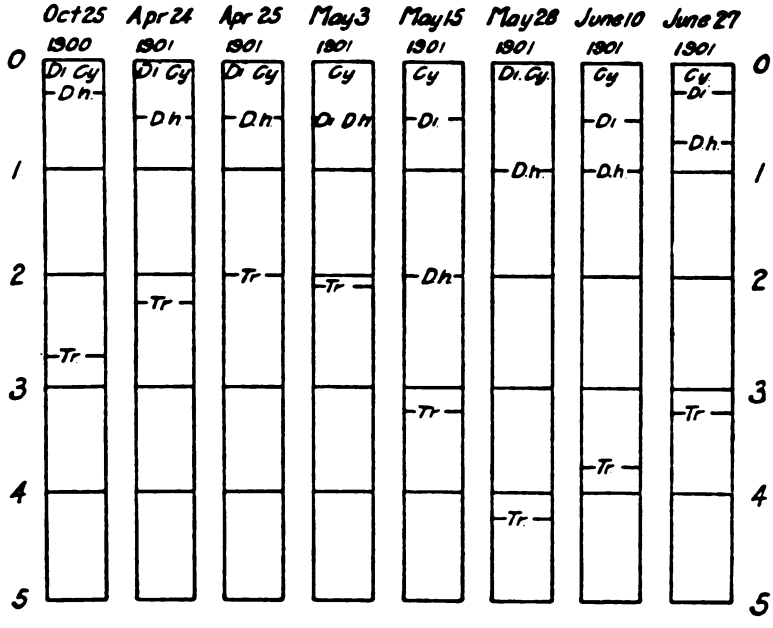

FIG. 2.—Vertical distribution of crustacea in Lake Mendota. For explanation see text, p. 565.

view. The position of *Daphnia hyalina* (D. h.), *Diaptomus* (Di.), and *Cyclops* (Cy.) is indicated in the figures and shows the upper limits of adults in the daytime. *Daphnia hyalina* is omitted in two cases, as it was not found in Green lake and only young were taken in Oconomowoc lake in October. These figures show that the depth to which the adults of these genera descended in the daytime was practically independent of the degree of transparency of the water. This was true not only of the different lakes but also of the same lake at different times. In Okauchee lake, the transparency was fifty per cent. greater in October and June than in August, yet the day position of *Daphnia hyalina* was the same in the three months. In Ocono-

mowoc lake, this crustacean was five meters nearer the surface in the day catches of June than in August notwithstanding the fact that the transparency was fifteen per cent. greater in June.

The fact that some species of crustacea left the surface two hours or more before sunrise, seems to indicate also that light is not the only factor involved. At this early hour, there was little if any more light than at midnight. Certainly the difference in the amount of light between midnight and two hours before sunrise was not as great as that between a dark night and a moonlight one, yet moonlight had no noticeable effect on diurnal movement. With comparatively few exceptions, however, light was the primary factor in causing the crustacea to descend in the morning.

It seems probable that several factors are instrumental in causing the upward movement of the migrating crustacea when the intensity of the light becomes sufficiently low. A negative geotropic reaction would cause a movement toward the surface as soon as the repelling force of light becomes so small that it does not counteract the upward tendency resulting from negative geotropism. As Ostwald (10) has suggested also, it may be due in part to active wandering. It seems appropriate also to apply the term "nocturnal habit" to the movements of some forms. This term is especially applicable to the horizontal migrations of the littoral forms.

In conclusion, it may be said that these results show that diurnal movement is not a simple phenomenon which may be attributed to a single factor. On the contrary, the movement in each lake presents complexities which can be solved only by complete observations that cover a considerable period of time. Light is the chief factor causing the downward movement of the crustacea and other factors are probably responsible for their upward movement. The effects of light are modified by temperature, the quantity of phytoplankton present, and the substances held in solution by the water.

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Waterhen Lake, Kinistino, N. W. T., Canada.

Marsh Hawk, wounded.

R. T. Congdon.

SASKATCHEWAN BIRDS.

RUSSELL T. CONGDON.

EXPLANATORY.

The observations recorded in this paper were made during part of the spring and summer of 1902, in the Saskatchewan River region, N. W. T., Canada.

Starting from Prince Albert, N. W. T., as a center, the greater part of the work was done in the territory lying from thirty to seventy-five miles southeast of Prince Albert. In general, this is prairie country with an abundance of small timber, mostly stunted poplar, growing in small tracts or groves called by the inhabitants, "bluffs." Scattered over almost the whole of this territory are innumerable sloughs,—shallow rush- or grass-grown ponds or pools,—and small marshy lakes. On the lower tracts, where the sloughs are most numerous, bush willows grow profusely, bordering almost every slough, and gathering in clumps in the marshy spots. Located in this strip of country are several fair-sized lakes: Water-hen Lake, frequently referred to later on, is very shallow, probably not more than eight or nine feet deep in any place. It consists of two arms of about equal length which, together, measure nearly twelve miles. It is probably not more than three miles across at the widest point. Almost the whole lake is grown up with reeds, and, during a dry year, it is practically a large marsh. A picture of this lake is shown in Plate XLI. It is drained by the Carrot River which enters at the head of one arm and leaves near the elbow. In the southeastern part of the district are situated Basin Lake, Middle Lake, and Lake Lenore. Here the country is more broken and hilly and the lakes are deep. There is more and larger timber, too, the lakes being surrounded by it. Basin Lake is six miles across, almost round, and the land rises con-

siderably as it recedes from the shores. The water of the lake has apparently risen in recent years, for the timber does not stop at the water's edge but extends out for some distance, so that almost the whole lake is bordered by the bark-denuded trunks of trees long dead, standing with five or six feet of their bases below the surface of the lake. From Basin Lake there is a narrow strip of low, marshy land extending to Middle Lake, less than half a mile away. Through this low strip a well-marked creek bed, filled with water, extends from Basin Lake to within a very few rods of Middle Lake and there abruptly ends, disappearing where there is a slightly higher strip of land on the edge of Middle Lake. The last named lake is smaller and there are numerous low islands in it. Lake Lenore, a few miles farther southeast, is the largest of the three, being about twelve miles long including the arm on the north, and about four miles across. The lake is surrounded on two sides by high hills. The shores of the arm, differing from the shores of the main body of the lake and of the other lakes, are thickly strewn with a mass of large and small boulders. The water in Basin and Middle Lake is very bad, being hardly fit for use in making tea, to say nothing of drinking purposes. As Lake Lenore has an outlet during rainy years, the water is better. Crooked Lake, at the head of the Carrot River, is long, narrow and, as its name signifies, crooked. Its shores are high and covered, in great part, by timber. It has much the appearance of a large river, and may possibly have been formed from an old river bed.

Such, roughly, is the character of the region investigated. As may be imagined, many water-fowl resort annually, for breeding purposes, to this locality, where there is an abundance of suitable food and, as yet, little disturbance from the inroads of man.

Of course, no claim is made as to completeness of the list. Many species were overlooked, no doubt, and others which were observed are not included in the list because of the unfamiliarity with them, and failure to secure specimens.

It should be mentioned that the spring of 1902 was considered by the inhabitants of this region very wet, cold, and backward, and this doubtless had much to do with the late and scattered nesting of many of the birds.

The descriptions and measurements of nests and eggs given in this report were either made in the field, as in the case of the bulkier nests, or taken from specimens collected in the region in

question during the season of 1902. In a few cases where specimens of uncertain identity were taken, these were sent to Washington, D. C. and the Smithsonian Institution very kindly identified them as nearly as possible. Mention is made of this under the headings of the species in question.

The nomenclature followed is that of the American Ornithologists' Union Check List of North American Birds. I wish to express my thanks for valuable assistance rendered by Prof. R. Ridgeway, and Prof. C. Dwight Marsh of Ripon College.

RUSSELL T. CONGDON.

Ripon, Wisconsin, February 2, 1903.

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1. WESTERN GREBE.

Aemophorus occidentalis (Lawr.).

The Western Grebe is by no means a common bird in the locality designated. Only three individuals were observed and no nests of the species were found. In Prince Albert there is a specimen, mounted, which was caught by some section men after it had flown against a telegraph wire in the neighborhood of Saskatoon, N. W. T. The individuals observed were seen swimming low in the water with only their long necks, white in front, and their heads, above the surface. On being followed by a boat, they immediately dived from view.

2. HOLBOELL'S GREBE.

Colymbus holboellii (Rienh.).

This large Grebe is a common summer resident in the region under discussion. It makes its home in the large and small lakes, not often being found in the sloughs, where the smaller Grebes are nearly always present. It was found nesting in large numbers at Water-hen Lake, Lake Lenore, Crooked Lake and other smaller lakes.

The bird has a peculiar hoarse cry which can be heard at most all hours of the day or night, but is heard most commonly when one approaches a nesting colony. The Grebe, however, is

very retiring in its habits, hiding in the reeds, or seeking a more distant part of the lake when approached, rarely allowing one to come within gun-shot of it. It may be present in considerable numbers and be unnoticed except by the more careful observer. It is an excellent diver like others of the family.

The nest of Holboell's Grebe is similar in construction and situation to that of other Grebes, but much larger. The upper picture in Plate XLII shows one of these nests. It is a mass of water-soaked and half-decayed grass, reeds, and other vegetation, mixed with mud and other debris. The nest is fastened to the rushes or grass in which it is built, and is sometimes very well concealed, but many of the nests observed were very openly situated. Although floating, the larger part of the nest is submerged, the upper part being just enough above the surface to keep the eggs out of the water. The size of these nests as would be expected, varies much. Of several nests measured at Crooked Lake, the average seemed to be about nineteen inches outside diameter, and six and one-half inches inside diameter. The depth, outside, two and one-half inches; inside, one and three-fourths inches. The depth was measured above the surface of the water, the nest extending several inches below the surface. Nests in a colony of about thirty pairs of birds at Glen Lake, averaged much larger, one measuring three feet, four inches, outside, and nine inches inside diameter; and two and three-fourths inches outside, and two and one-fourth inches inside depth. The birds were found nesting both in isolated pairs and in colonies of considerable extent. At Crooked Lake, the nests were placed in the narrow belt of rushes, bordering the lake at different points. At Glen Lake, where there was a colony of considerable extent, the nests were fastened to the grass growing in the water on the border of a low island. Here, on approaching the colony in a boat, the birds were seen through a field-glass, standing on their nests and drawing debris over the eggs to hide them from view. Part of the nests were found uncovered, probably because the birds were compelled to take too hurried departure. A crow had a nest on the island in close proximity to the colony, and the broken, empty egg shells lying about gave sufficient evidence of his ravages among his neighbors, the Grebes.

The number of eggs found in a nest ranged from one to six, none containing more than that number, while four and five

Nest of Holboell's Grebe.

Nest of Forster's Tern.

Photo by R. T. Congdon.

seemed to be the usual nest complement. Sets containing less than four were probably incomplete and none such were found in which incubation had commenced. The shape of the eggs is oval or elliptical, somewhat larger at one end than at the other. In color they are bluish or greenish white when freshly laid, but they become stained light brown by contact with the decomposing vegetable material used in the construction of the nest. They vary greatly in size, specimens measuring from 1.89 inches to 2.26 inches long, by 1.32 inches to 1.45 inches broad. The average size of thirty-five specimens measured is 2.14 inches by 1.40 inches.

The first eggs were taken May 23, when none but fresh eggs were found. Fresh eggs were also taken June 4, and several nests containing eggs were observed as late as July 6.

3. Horned Grebe.

Colymbus auritus (Linn.).

This little Grebe was also found to be a common summer resident. Its favorite home seems to be the smaller grass-grown lakes and sloughs. In common with the other Grebes, it has wonderful powers as a diver. It is very interesting to see one suddenly disappear below the surface of a body of water, leaving hardly a ripple to show where it formerly rested.

The nest of the Horned Grebe is very similar in construction and situation to that of the next species,—the Eared Grebe, no general difference being observed. This Grebe, like the others, generally covers its eggs with debris, when it leaves the nest. This apparently, is to protect them from the Crows and other enemies who enjoy a feast of fresh eggs; or it may be, as some suppose, that the decaying vegetation with which the eggs are covered supplies heat which aids in the process of incubation.

Nests containing eggs were observed from the first of June to the middle of July. A set of five eggs, taken June 7, at Waterhen Lake, measure 1.65x1.17, 1.66x1.19, 1.67x1.18, 1.65x1.16.

Many of the eggs of the Horned Grebe, observed, seem to be of a more greenish tint when fresh than those of the Eared Grebe, and more of a coppery color, or duller, after they have remained in the nest for some time. Eggs of the two species, however, cannot be distinguished, with any certainty, from each other.

4. American Eared Grebe.

Colymbus nigricollis californicus (Heerm.).

The Eared Grebe was found in considerable numbers in the numerous reed- and grass-grown sloughs and, also, in the larger lakes of the territory investigated. At Water-hen Lake it is a common bird, making its home in the thickly growing rushes near the shore of the lake, often building its nest in close proximity to the nest of the Holboell's Grebe. The Eared Grebe, like other Grebes, often forms extensive colonies during the nesting season. At Water-hen Lake, one colony observed contained hundreds of nests and these were situated so close to one another that between thirty and forty could be seen without changing the position of the boat, and it required much care to force the boat through the "bird-town" without destroying some of the "homes." The nests were built by piling up decayed and water-soaked reeds, grass and other material, apparently brought from the bottom of the lake by the birds, this material being placed on a few reed stalks bent down to the water level and serving to support the nest and moor it among the reeds. One of the nests observed, is shown in Plate XLIII. The nature of the material used in constructing the nest causes it to sink low in the water so that the depression in the top, which contains the eggs, is only a little above the water level. In fact, some of the nests were so low in the water that a little water stood in the nest. The nests varied much in size. A nest which may be taken as a fair example, measured eleven inches, outside diameter; four and one-half inches, inside diameter; two and one-half outside depth, and one and one-fourth inside depth. Many of the nests were so situated that they were quite well hidden by reeds and rushes, while others were more openly placed and could be seen at some distance. When this colony was first visited, July 6, most of the nests contained three or four eggs while a few held but one or two. Of several sets taken on this date, the eggs were either fresh or incubation had just commenced. Returning again, August 4, most of the nests were found deserted, the eggs having hatched; but several still contained eggs advanced in incubation. Nests containing fresh eggs were also found as early as the 5th and 11th of June. This shows a range of two months in the time of nesting. The number of eggs laid by this bird ranges from three to seven but most of the nests observed con-

Nest of American Eared Grebe.

Nest of Coot.

to by R. T. Congdon.

Floating nest of Loon

Nest of Canada Goose.

R. T. Congdon.

tained four or five. These eggs are a pretty bluish or greenish white when laid, but soon become stained brown and often have numerous bits of the nest material adhering to the shell. Frequently a nest is found in which the egg most recently laid is light blue and unsoiled, while the remaining eggs of the set are stained light brown. The eggs are oval in shape, and, as a comparison of many specimens taken seems to show, of a more elongated oval than eggs of the Horned Grebe. The average size, of ten eggs taken from a number of different sets, is 1.76″x1.18″.

7. Loon.

Gravia imber (Gunn.).

Although the Great Northern Diver, as the Loon is often called, is not a common bird in this locality, several pairs were seen on the larger lakes. On Crooked Lake there were two or three pairs, and their peculiar and piercing cry could frequently be heard. The actions of the birds seemed to show that they had nests on this lake but none were found here. At Glen Lake, a smaller lake about seven miles from Crooked Lake, two nests were found. The first one found on May 26, contained but one egg and was not disturbed; the second, found on the same day, contained two eggs which, on being blown, proved to be slightly incubated. While the nest was being examined, the pair of Loons swam about, a little distance out in the lake. The nest was similar to that of Holboell's Grebe, being composed of reeds, grass-roots, mud and rushes, floating in the water, with much of the mass below the surface. It was moored to a stump or stake, in open water near the edge of a low island. It was in a very exposed situation, not being hidden by any grass or rushes whatever. This nest is pictured in Plate XLIV. The nest measured twenty-three inches in outside diameter and ten inches inside diameter. The height of the nest from the top to the water was two and one-half inches, and the depth of the hollow, one and one-half inches.

When the first nest was again visited eight days later, June 3, it still held but one egg, which was cold. On blowing, it was found to be fresh. Apparently the nest had been deserted by the birds. This nest was similar to the other, being a floating mass of partly water-soaked vegetation, moored among grass near the edge of a small, low island. It differed from the other in that

there was some grass growing about it, affording, however, very little concealment. In size, it measured the same as the other nest, with the exception of its being three-fourths of an inch deep. When first observed, the nest was on the southwest shore of the island. The following week, a storm drove the waves against the side of the island and, when the place was visited again, on June 3, the nest had been moved to the north east side of the island, where it was found fastened among the grasses. This was rather surprising, and no plausible explanation was offered other than that the birds had moved it to obtain shelter from the storm.

One Loon was winged with a shotgun and could not take to flight with its mate; but it dove, apparently with as great ease as ever, and kept out of gunshot.

The eggs of the Loon are very dark in appearance, the ground color being olivaceous brown, spotted with very dark brown or almost black. The spots are small, mainly under one-eighth inch diameter, and scattered evenly over the whole shell. The three eggs measured: 3.29x2.01; 3.53x2.12; 3.46x2.16.

69. Forster's Tern.

Sterna forsteri (Nutt.).

This bird was found to be very abundant, especially in the neighborhood of the larger lakes of the region. It is an easy and graceful flyer and very expert in catching its food, which it does by dropping rapidly to the water's surface to rise again with the morsel in its bill. These Terns always congregate in colonies when the time for nesting arrives. They are, in general, late nesters; for, several sets of eggs taken July 6 were fresh and some nests were found containing incubated eggs as late as July 29. However, young birds were observed on the wing on the last date, July 29, and a few nests containing eggs were seen as early as May 26. Thus there seems to be a probability that two broods are raised in a season. The Forster's Tern was particularly numerous at Water-hen Lake where two separate colonies were observed. The nests were built on masses of dead, floating reeds, among the thick rushes growing in the water. They were made of reed stems, rushes, and other debris, with a saucer-shaped depression in the top, sometimes lined with finer material such as grass. A good example of the nest of this bird is

shown in Plate XLII. A typical nest measured twenty-eight inches, outside diameter; and four and three-fourths inches, inside diameter. The outside depth was four inches; and inside depth, one and one-half inches. Often several nests were so closely placed as to join one another and generally these groups were situated in small, open patches of water where no reeds were growing for an area of a square rod or a little less. Several of these nests were found in the colony of the Eared Grebes, before spoken of, and the nests of the two species were situated within two or three feet of each other.

The nest complement seems to be three eggs although several nests held four. However, the variety of markings in such nests seemed to point to the probability that the eggs were laid by more than one bird.

The eggs of the Forster's Tern vary from brownish to greenish in ground color, more or less thickly spotted and blotched with dark brown and pale black, generally with obscure shell markings of lilac. The marks are, as a rule, rounded and uniform in shape, but on some specimens they take the form of very irregular scratches and blotches. One specimen is of a very light blue color and almost entirely unmarked except for a blackish scroll encircling the larger end like the letter "C."

When a colony is approached, the birds rise from their nests and fly about, sometimes making dashes at the intruder and coming into uncomfortably close proximity to his head. They continue to keep up the chorus of harsh, grating cries while one remains in the neighborhood of the nests. If one of their number is shot, they hover and dart with increased noise just above the spot where the bird has fallen to the water, and continue this until the wounded bird ceases to show signs of life.

77. Black Tern.

Hydrochelidon nigra surinamensis (Gmel.).

The Black Tern, or Black Gull as it is called in this locality, is by far the most numerous representative of the Tern family. Not only is it common about the larger reed or grass bordered lakes, but almost every slough of any size, also, has its Black Terns, continually dashing about on the wing and darting after the insects which constitute their food.

This Tern, too, nests in colonies though these are not often of so great extent as those of the Forster's Tern. Most of the nests of this bird were found in grassy sloughs, from six to fifteen being the number of nests in a colony. They were placed on masses of dead grass, reeds, or other vegetable substance, floating among the grass or reeds of the slough. The material used in building the nests is generally grass, but, when the nest is situated in a reed and rush grown slough, the material used is small pieces and bits of rushes with a lining of finer material. A slight depression in the top of the pile serves to keep the eggs from rolling off into the water. An average of several nests measured is: diameter, outside, seven inches, inside, three and three-fourths inches; depth, outside, one and one-half inches, inside, one inch. Some of the nests observed were very flimsy affairs, apparently only a slight hollow being scraped out in a mass of floating debris. Unlike the Forster's Tern, no nests of the Black Tern were found placed in very close proximity to each other. Each nest had its own little area, at a distance of several feet from the other nests of the colony. Like the Forster's Tern, these birds also make a great disturbance when their breeding grounds are approached. One day when a duck was shot in the neighborhood of a colony of Black Terns, these birds immediately gathered in numbers and hovered about above the wounded duck, making a great disturbance until the bird ceased splashing in the water.

At Water-hen Lake, the Black Tern could be seen at all hours of the day, flying up and down over the rushes bordering the shore, in search of food. In the evening they habitually came ashore and flew about over the fields in great numbers, apparently after the mosquitoes which were particularly numerous at that time. Sometimes they were seen to gather near one spot along the shore of the lake, and circle about in the air like a swarm of bees.

The number of eggs laid by this bird is generally three, but nests were found containing only two eggs, in which incubation had commenced. A few nests were found containing four eggs, the eggs of a nest bearing a close resemblance to each other. Although it is possible that the eggs of such sets were laid by more than one bird, it seems probable that the Black Tern occasionally lays four eggs at one brooding. The eggs of this bird are too well known to need description here. The first nests containing

eggs were found on June 8, and fresh eggs were also taken June 20 and July 2. Young of the Black Tern were observed flying, on July 26. Frequently one can see two or three of the young, resting on broken down rushes or floating debris, while the parent birds fly about near at hand, searching for food to bring to their infants. If one approaches the spot, the parent birds make a great fuss as if fearing for the welfare of the young; but when closely approached, the young birds take to wing and join in the cries of the old birds as if to show that they are well able to look out for themselves.

120. Double-Crested Cormorant.

Phalacrocorax dilophus (Swains.).

The Double-crested Cormorant was found in considerable numbers in suitable places throughout this region. It was generally observed about the shores of the larger, more open lakes, perched on the limbs of dead trees, or on rocks near the water's edge. When approached, it usually takes to wing, alighting in the water a short distance from the shore. The Crow-duck, as it is called by the natives, is very much like the Loon in shape, and is a good diver. It frequently flies a considerable distance from one body of water to another, in its search for food, which consists mainly of fish.

At Crooked Lake the birds were seen in considerable numbers, but a search failed to reveal their nests. At Basin Lake, however, better success was met with, for at that place, some thirty or more nests were found in a colony on the lake shore. Their choice of a nesting place was somewhat peculiar. Most of the lake is bordered by timber which reaches to the water's edge, and in many places extends out into the water for some distance. Picture, if you can, a slashing of dead timber, standing in water six or eight feet deep, many of the trees fallen, with their branches just above the surface; others half fallen, with their trunks crossing and resting on other fallen or standing trees. It was such a tangle, almost impenetrable, that the Cormorants had chosen as the site of their rookery. Here the nests were built, placed in the low branches or on the slanting tree-trunks when a crossed trunk or a projecting limb afforded a sufficient support. The nests were situated at a height of from three to nine feet above the surface of the water. The place could be reached only

by water, and it was a difficult matter to work the boat through the tangle and get at the nests. In some places, three or four nests were situated within a yard or so of each other but, as a rule, they were more scattered. The nests were made principally of sticks and twigs measuring from eight inches to a foot and a half in length. The materials used to line the depression were grass and weeds. A nest which may be taken as one of average size, measured twenty-four inches, outside diameter; eleven inches inside diameter; ten inches outside depth; and four inches inside depth. Most of the nests contained four eggs, only one containing as many as five. In sets containing this number, four, incubation had commenced, while eggs from nests containing a smaller number than four proved to be fresh. In color they are light blue. There is deposited on the surface, a layer of whitish chalky substance which can easily be chipped off. They are elongated in shape and slightly larger at one end. After becoming nest-stained they resemble eggs of Holboell's Grebe. The average size of fifteen specimens measured is: 2.41 x1.49. They vary from 2.28 to 2.61 in length, and from 1.39 to 1.58 in width.

The Cormorants kept up a continual squawking or chattering noise which could be heard at some distance from the rookery. When the observer approached to within a couple of rods of the rookery, the birds flopped off the nests into the water, and, with a great noise, scrambled to the open and took wing. They continued to fly about over the place while their domain was being disturbed.

125. American White Pelican.

Pelecanus erythrorhynchos (Gmel.).

A few of these birds were seen on some of the larger lakes, but the only place where they were found in any number was Lake Lenore. Here a flock of one hundred or more was seen. They were swimming about at the inlet of a creek emptying into the lake, apparently searching for fish. On being approached, they took to wing, breaking up into several smaller flocks, part of them settling on the lake a short distance away and others flying to a considerable distance. They were seen continually coming to and leaving the lake, in flocks of eight or ten, or by twos and threes or, occasionally, one alone. Their manner of flying is

somewhat peculiar: A few measured flaps of the wings are given and then the bird sails for a short interval, this change being made at regular intervals. It is amusing to see the Pelicans take to wing from the surface of a body of water. They cannot rise immediately but must paddle along the surface for a little distance, somewhat after the manner of the Coot or some of the Ducks. The Pelicans do not strike the water rapidly with one foot after the other, like these birds, but the two feet are moved together six or seven slow strokes aiding the bird in rising. The favorite fishing ground of the Pelicans seems to be at the mouth of a creek flowing into a lake. They were observed swimming about such places as late as twelve o'clock at night.

The breeding grounds of this bird were not discovered.

132. Mallard.

Anas boschas (Linn.).

The Mallard, or Stock Duck as it is more commonly called by the inhabitants, is a common summer resident. The first nest of the Mallard was found on May 22. It was situated on the ground near a grass-grown slough, and was partially hidden from view by an overhanging bunch of grass. The hollow was lined with grass and a few dried leaves, and held nine slightly incubated eggs. Another nest, found on June 6, contained four little ducks, just out of the shell, and six eggs chipped and about to hatch. The female Mallard left the nest when it was approached, thus betraying its situation. The nest was built at the base of a clump of willows, on slightly raised ground, over the willow roots. It was a slight affair, being merely a hollow lined with grass. The willows were about ten feet high and surrounded by many similar clumps. The place was low, near a lake shore, and had recently been flooded so that water reached almost to the level of the nest.

The eggs of the Mallard are light olive green in color. The sizes of some of the specimens measured are as follows: 2.20x 1.61; 2.29x1.59; 2.35x1.62; 2.29x1.63 and 2.31x1.62.

139. Green-Winged Teal.

Anas carolinensis (Nettion.).

This pretty little duck, though not as common as the Blue-winged variety, is by no means scarce. Although a good table duck, it is not especially sought after by the hunter because of its small size.

The nest is built on the prairie, usually not far from a slough or other body of water. Often a slight knoll is selected, a hollow scratched out, and down from the breast of the bird used for a lining. A tuft of tall grass or some weeds hides the nest from view. The female is a very close sitter especially when incubation is far advanced. In one case, a team of horses and wagon was driven over a nest, a horse passing each side of it, and the duck flew out between the horses feet. This nest was placed at the base of a cluster of raspberry bushes, about thirty inches high, and was entirely hidden from view. The nest was only a few feet from a field of grain. A hollow had been scraped out and lined with small twigs from the berry bush, grass, and a layer of down particularly thick about the rim. The nest contained nine eggs which were far advanced in incubation. Two pictures of this nest are shown in Plate XLV.

On two occasions, when the nest was visited late in the afternoon, the bird was away and the eggs were entirely hidden from view by a covering of down and bits of grass. When the bird was found on the nest, she would not leave until one approached within about three feet of the nest, when she would flutter off and fly for a short distance then drop into the grass as if wounded. Eggs from this nest measure: 1.70x1.23; 1.71x 1.22; 1.76x1.20. The eggs of the Green-winged Teal are of a buff or cream color and, probably not distinguishable from the eggs of the Blue-wing.

140. Blue-Winged Teal.

Querquedula discors (Linn.).

The Blue-winged Teal is perhaps the most numerous of the ducks observed. During the nesting season, single males were frequently seen feeding in the sloughs, probably not at a great distance from the little wife so busily engaged in her household duties.

Nest of Green-winged Teal.

Same nest as above removed from original position.

Photo by R. T. Congdon.

The nest of this Teal is very similar to that of its near relative, the Green-wing. The place chosen for a site is usually on the prairie where the preceding year's growth of grass has not been burned over. Here, not far from a slough or other body of water, a hollow is scratched out beneath an overhanging bunch of grass. This is lined with fine grass and a warm bed of down from the breast of the duck. One nest observed was situated on a knoll between two sloughs. The long, dry prairie grass almost hid the nest from view. The hollow lined with down, was six inches in diameter and two inches deep. It contained eight eggs and another, broken, was lying on the ground about two feet from the nest. The nest was near a badger's den and apparently had been disturbed by that animal. The earliest date on which eggs of the Blue-winged Teal were found was May 31. The nest was situated under a low bush and held eleven fresh eggs. On June 27, a female Teal was seen to leave her nest with four or five young just hatched, three eggs being left in the nest. On July 2, a duck of this variety was seen with a brood of eight young about two weeks old. The Teals, both the Green-winged and the Blue-winged varieties, receive more than their share of annoyance from the Crows and some of the animals which now and then feast on eggs. Many nests were found with the egg shells scattered about, emptied of their contents.

The eggs of the Blue-winged Teal are very similar to those of the Green-winged variety. Their color is buff or light cream. The average size of thirteen eggs measured is: 1.83x1.32.

142. Shoveller.

Spatula clypeata (Linn.).

The Shoveller is one of the most handsome ducks of this locality. The beautiful attire of the male with its glossy, greenish black head and neck, silvery white fore-breast, blue-wing coverts, and brown under parts, contrasting so strongly with the plain dress of the female, is very striking. The bill, long and rounded, and with many large liminae, is altogether peculiar, and gives the bird the name of Spoonbill among the inhabitants.

A nest found on June 5, was thought to belong to this bird. It was situated on the ground in long, dry grass near the edge

of a small body of water. The hollow was lined with grass and a little down. The nine eggs which the nest contained, were fresh. They are greenish buff in color, and average 2.09x1.44. The smallest measure, 1.99x1.40; the largest, 2.15x1.47. Specimens of these eggs were sent to the Smithsonian Institution and identified as probably eggs of the Shoveller.

143. Pintail.

Dafila acuta (Linn.).

This Duck is easily identified by its long, slender neck and very long, sharply pointed tail. The nest is usually built in the tall prairie grass in close proximity to water, though sometimes it may be at a considerable distance from any creek or other body of water.

A nest of the Pintail was found on May 14, containing nine eggs, in which incubation had commenced. The site chosen was on the prairie under a low bush. The nest was well lined with down, mixed with a little grass and bits of dry leaves. The color of the eggs from this nest is light bluish or greenish, and the surface of the shell is very smooth. Several of the eggs measured as follows: 2.10x1.52, 2.16x1.48, 2.17x1.50, 2.22x 1.46, and 2.20x1.48.

146. Redhead.

Aythya americana (Eyt.).

This large and rather handsome Duck was found to be not uncommon on the sloughs and shallow lakes of this region. In general appearance, it is very similar to the Canvas-back and is sometimes confounded with it. Among other features, however, the shape of the bill and head, alone, will serve to distinguish them. The bill of the Redhead is considerably shorter than that of the Canvass-back and the forehead rises from the base of the bill in an abrupt arch while the Canvas-back's forehead rises in a gradual slope, following the line of the bill.

The nests of the Redhead were invariably found in grass or reed grown sloughs, or among the rushes on the border of shallow lakes. They are situated similarly to the nests of the Coot, being basket-shaped piles of rushes or grass, or both, resting partly in the water. The Redhead's nest is situated in shal-

Redhead Duck.

Nest containing eggs of both Redhead and Canvas-back.

y R. T. Congdon.

lower water than that of the Coot, as a rule, and in a thicker growth of grass or rushes which afford it better concealment. A mass of vegetation is heaped up on some broken-down rushes or grass, a rather deep hollow is made and lined with grass and a little down. The nest will rise and fall with the water to a certain extent, but this motion is usually limited by those rushes, used in its construction, whose roots are still fast in the bottom of the slough or lake. A nest of the Redhead is shown in Plate XLVI.

147. Canvas-back.

Aythya vallisneria (Wils.).

The Canvas-back is conspicuous among the ducks observed, commonly frequenting during the nesting season the sloughs bordered by grass or rushes with an area of open water in the center. Frequently the male bird would be seen swimming about in the open water in the neighborhood of a nest, and the female, on being flushed from the nest, would join her mate. A big drake was shot on August 6, and the throat and crop contained watersnails.

The nesting site chosen by the Canvas-back is very similar to that of the Redhead and the nest itself differs from the nest of the Redhead but little, if any. The place generally chosen is a clump of tall grass growing in a slough where the water is from a foot to two or three feet deep, or it may be a cluster of rushes in the deeper water of a slough or shallow lake. Here, some of the grass or rushes are broken down and a large amount of dead grass or reeds is piled up and deeply hollowed. Then a cosy lining and rim of down is added. The nest may be well hidden by surrounding clumps of grass, but usually it is built near small, open stretches of water. A typical nest is pictured in Plate XLVII. One nest, situated among the rushes of a deep slough, could be seen from a distance of three or four rods. It was rather larger than most of the nests of the Canvas-back, measuring thirty-six inches outside diameter; eleven inches inside diameter; eight and one-half inches outside depth and four and one-half inches depth inside. Another nest was built up from the bottom of a slough where the water was about a foot deep. It was but slightly hidden by the bunch of grass in which it was built. A nest of the Canvas-back containing eight eggs of that bird and eight of the Redhead, is shown in Plate XLVI.

One nest observed, was rather odd in its location. It was built in a bunch of low bush willows growing in tall grass in the edge of a slough. The willows and grass supported the sides of the nest, the lower part of which rested in the water.

There seems to be considerable range in the time of nesting. The first nest was found on May 23, and contained seven fresh eggs; the last nest, containing eggs, was found on July 2 and five of the six eggs it held were chipped and about to hatch. Eggs but slightly incubated were taken as late as June 21. The number of eggs found in a nest was from five to eleven. Only one nest contained as many as eleven, the majority containing six or seven.

The eggs of the Canvas-back are oval, slightly larger at one end. The surface is smooth. In color, they are very light green or bluish green. Of forty specimens measured, the sizes vary from 2.31 to 2.60 long; and from 1.63 to 1.83 broad. The average size of these specimens is 2.53x1.72.

149. Lesser Scaup Duck.

Aythya affinis (Eyt.).

The Lesser Scaup or Blue-bill as it is commonly called, is a common duck in this region. The nest of the Blue-bill is usually situated on the ground, near a marshy place or slough. A depression is made in the sod and lined with grass and a little down. One nest observed was situated on a mound, probably an old ant-hill, about nine inches above the surrounding prairie. It was only a few feet from a trail and the bird left the nest every morning, for a period of several days, as one of the settlers passed on the trail. The nest was about two rods from the edge of a slough, bordered by bush willows. The bird was taken that the identity might be certain. On June 20 the nest contained eleven eggs slghtly incubated. The hollow, lined with a little grass and down, was eight inches in diameter and two and one-half inches deep. Grass growing on the mound hid the nest from view.

The eggs of the Lesser Scaup Duck are elliptical in shape and of an olive-gray or buff color. The average size of the eleven eggs taken from the nest, described above, is 2.29x1.60.

Nest of Ruddy Duck.

Nest of Canvas-back Duck.

y R. T. Congdon.

153. Buffle-head.

Charitonetta albeola (Linn.).

The Buffle-head, or Butter-ball as it is called by many, is a common bird in this region, particularly about some of the timber-bordered lakes. The nesting site of this duck is, like that of the Wood Duck, the hollow of a tree or stub. No nests were discovered.

167. Ruddy Duck.

Erismatura rubida (Wils.).

The Ruddy is another of the more beautiful ducks observed. The general color of the male, chestnut, with the contrast of black and white, make him a beautiful bird. The Ruddy seemed rather more wary than some of the birds and rarely allowed one to approach within gun range. The nest of this duck is a basket-like affair of rushes or grass half floating on the water, and partly supported by the reeds among which it is built. It is deeply hollowed and lined with grass of finer rushes and a little down from the bird's breast. It is very similar in situation and construction to the nests of both the Canvas-back and the Redhead. In no case was the parent bird seen leaving the nest, and some of the nests were almost stepped on before they were seen because of their nearly complete concealment in the thick, tall grass. Perhaps it is safe to say that, in general, the nests of the Ruddy Duck were found in taller, thicker grass, nearer the borders of sloughs, than the Canvas-back's and Redhead's nests, and more perfectly hidden from view. A nest, found June 27, containing ten eggs, was of an average size. It measured eighteen inches outside diameter, seven and one-half inches inside diameter; seven inches outside depth, and four inches inside depth. The nest shown in Plate XLVII is hardly a typical nest of the Ruddy, being too flat.

The number of eggs found in a set was from six to ten. In most cases, incubation had begun by the middle of June. The eggs of the Ruddy are rather peculiar, for duck's eggs. In color they are almost pure white when freshly laid, but become stained and soiled from contact with the nest. The shell is coarse-grained and pitted. Their shape is oval, slightly larger at one

end. The sizes range from 2.32x1.77 to 2.63x1.83, the average size of specimens measured being 2.49x1.80.

On several occasions, two or three eggs of the Ruddy were found in nests which were merely low platforms of broken-down grass, resembling closely the nest of the bittern. In one nest of the Ruddy, there were two, and in another, three eggs much smaller than Ruddy's eggs and of a greenish color. They were evidently laid by some other variety of Duck. Plate XLVIII shows a nest of the Bittern containing two eggs of that bird and one of the Ruddy.

172. Canada Goose.

Branta canadensis (Linn.).

Although most of the geese go farther north to spend the summer and rear their young, a few were found nesting about some of the lakes of this region. At a ranch on the shore of Glen Lake, where a stop was made, there was a Canada Goose which had been captured the year before, when only a few days old. Its wings were clipped and it wandered about in and out of the cabin at will. It was at this place, Glen Lake, that the first nests of the Canada Goose were found. On a low, gravelly island in the Lake, two eggs were found and parts of the shell of two others. The two eggs were partly chipped and contained goslings, ready to hatch but dead. The eggs lay on a mass of rubbish which had, probably, been the nest. The water had recently risen and submerged most of the island, flooding the nest. The same day, May 26, on another island near by a nest was found containing three eggs in which incubation was advanced. The island was rather low and was overgrown with short grass and weeds. There were numerous small logs and stumps scattered about and among these—about three rods from the water's edge—the nest had been built. The base of the nest was a platform of small, long sticks and twigs. On this was placed a mat of fine grasses, the hollow being lined with a good supply of grayish down in which was mixed a little grass. The nest measured twenty-nine inches outside diameter, eleven inches inside diameter; five and one-half inches outside depth, and three and one-fourth inches inside depth. It was not hidden by grass or weeds and could easily be seen at the distance of a rod. The goose left the nest when the spot was approached,

Nest containing two eggs of Bittern and one of Ruddy Duck.

Nest of American Bittern.

Photo by R. T. Congdon.

and joined her mate out on the lake. The nest is shown in Plate XLIV.

At Middle Lake, on May 29, three nests were found containig four, six, and nine eggs respectively. The nest containing six eggs was situated near the central part of a low island. It was placed in a clump of very low bushes and close by a log and stump. Its presence was betrayed by the bird's flying up as the nest was approached. Grass and a few pieces of rotten wood were used in its construction, the lining being of grass and down. The eggs were advanced in incubation. On a low but dry island, about two rods across, was situated the nest containing nine eggs. It was built within two feet of the water's edge, but, as the water of the lake had recently risen, it is probable that it had been originally farther from the water. This nest was similar to the others but had only a little down in the lining. The eggs were far advanced in incubation. The bird left the nest as the island was approached and, alighting in the water a short distance away, was joined by her mate. They kept up their honking for some time.

The Canada Geese are early nesters and generally the eggs are laid soon after the ice is gone out of the lakes in the spring. On May 27, six yellow, downy little goslings two or three days old were caught along the shores of Glen Lake and taken to a ranch house. Two or three of them lived to reach maturity. There seems to be considerable range in the nesting time, however, for eggs not more than half incubated were taken as late as May 29.

The position of the nest was usually betrayed by the goose flying from the spot, uttering the peculiar honk-honk. Sometimes the goose was seen leaving the island before a landing was made. Through the nesting season flocks of five or six birds were observed flying from place to place to feed. It is probable that these birds were the young of the two previous seasons; for, it is held that the goose does not lay until it is three years old. The birds are rather wary and frequently two or three individuals would be seen waddling off across the prairie or through the long grass of a marshy place, with their long necks stretched and heads up, watching every move of the intruder.

The eggs of the Canada Goose are a soiled white in color. Eggs taken in this locality were much larger at one end, and rather pointed at the other. The average size of twenty eggs

taken at Glen Lake and Middle Lake is: 3.37x2.25. The largest measures 3.50x2.35; the smallest, 3.22x2.13. Eggs which have been in the nest some time are generally more or less stained and streaked with light brown.

190. American Bittern.

Botaurus lentiginosus (Montag.).

The Bittern, or Bog-pump, as it is appropriately called by some, is a common summer bird in the region, and its peculiar gutteral chunk-chunk can frequently be heard in the neighborhood of sloughs and swampy places. When flying, the crooked position of its neck, forming a hump below, gives it a peculiar appearance. Often, when closely approached, the bird stands erect with its neck outstretched and bill pointing straight upward. In this position it closely resembles a stick and is frequently mistaken for one.

The Bittern is retiring in his habits, and for a nesting site chooses some lonely place such as the tall grass of a slough, bordered by bush willows. Unlike their near relatives, the Herons, the Bitterns do not congregate in colonies to breed, but the pairs nest singly and the nests are difficult to discover. A rather crude affair serves the purpose of a nest. Where the tall grass grows thickly in the border of a slough, some of the blades are bent down to the water and on these, dead grass is piled. So the nest is merely a platform of grass or rushes, only a few inches above the water, and with but a slight depression to hold the eggs and prevent their rolling off. A nest of the Bittern is shown in Plate XLVIII. Sometimes, when the nest is built among rushes, the material used in the construction is rushes. Part of the material used in the nest lies in the water and the remaining part rests on this foundation. Nests observed were in water from eight to fourteen inches deep. The nests measure from fifteen to nineteen inches outside diameter and the top of the nest is from three and one-half to five inches above the surface of the water. The bird is a rather late breeder; for nests containing fresh eggs were taken as late as June 9 and 18. Five was the largest number of eggs found in a nest, while sets of three or four were more frequently found. The eggs are drab, with perhaps a greenish tint. They are elliptical in shape, some of

the specimens taken, being very short, almost round. The sizes vary from 1.81 to 2.30 in length; and from 1.43 to 1.52 in breadth.

194. Great Blue Heron.

Ardea herodias (Linn.).

Although this bird was not found in great numbers, individuals were occasionally seen following the courses of creeks or feeding along the borders of streams or lakes. As the bird flies by, overhead, with its long neck and its longer legs—the latter projecting behind on a downward slant—it presents an odd appearance. One of the settlers stated that large numbers of these birds nested in a colony at a small lake near Crooked Lake, but the place was not visited. The only nest of this Heron that came under observation was situated in the Cormorant colony at Basin Lake. The nest was similar to the Cormorant's nest but somewhat larger. It was situated in the crotch of a half-fallen tree, about nine feet from the surface of the water in which the timber was standing. The bird was seen to leave the nest. The material used in constructing the nest was sticks and twigs, the depression being lined with grass and weeds. The tree in which the nest was built was in a tangle of dead timber standing in several feet of water at the border of the lake. The nest contained five eggs which were well started in incubation. The eggs are greenish-blue in color, and elliptical in shape. The five eggs taken measure: 2.23x1.71; 2.30x 1.72; 2.38x1.75; 2.39x1.75, and 2.41x1.74.

202. Black-crowned Night Heron.

Nycticorax nycticorax naevius (Bodd.).

A hundred or more of these birds were found nesting in a colony at Water-hen Lake. Often about sundown ten or fifteen of the birds were seen standing in the shallow water along the edge of the Carrot River, or wading about on the muddy banks in search of food. This Heron is more stocky in build and has shorter legs and neck than most of the Herons and is not as ungainly in appearance.

The rookery of these birds was situated in the thick rushes not far from the shore of the lake. The rushes grew so thickly

that it was almost impossible to force a way among them with a boat. A few nests containing eggs, however, were examined. The nests were large piles of rushes placed among thick clumps of rushes. A depression in the top held the eggs. The nests rested on rushes, with the lower part in the water. They were eight or ten inches high, above the water. In diameter they measured from nine to fourteen inches, and the depth of the hollow was about two inches. When the colony was visited, July 6, the eggs examined were well advanced in incubation. Four was apparently the number most commonly laid. As the rookery was approached, the birds rose from their nests and flew about in a cloud, at a safe distance from the intruder. The eggs are oval-elliptical, and bluish-green in color. Specimens taken measure from 1.99x1.46 to 1.87x1.40. No eggs taken were as large as eggs of this Heron from Wisconsin.

206. Sandhill Crane.

Grus mexicana (Müll.).

Saadhill Cranes were occasionally seen flying over, or feeding in small flocks in the grain fields. Sometimes their antics, strutting about with outstretched wings and an up and down "bowing" movement, are very amusing.

No nests were observed, but one was reported by a native. It was said to be built near a spring in a marshy meadow.

212. Virginia Rail.

Rallus virginianus (Linn.).

This little Rail was frequently seen running about on the mud and vegetation in the edge of sloughs, in search of food. The bird has a peculiar walk, or run, moving its head and neck forward and backward and its tail up and down, in time with its steps. The shrill cry uttered by the Rail is sometimes rather startling. If one walks carefully through the tall, thick grass in the edge of a slough he may come upon a nest of the Virginia Rail with Mrs. Rail at home. If the bird is found on her nest, she will quickly and quietly slide off into the water and sneak away through the grass. When she has got away a little dis-

tance, she gives her piercing cry of alarm; or perhaps the cry is intended to allure the intruder away from the nest.

The nest is situated in a thick clump of tall grass, just above the water, and the grass-blades come together above the nest so as to conceal it from view, in a manner so natural as to attract no attention. The materials used in constructing the nest are grass-blades or rushes, with a lining of grass. The number of eggs found in a nest was from eight to twelve. A set of ten eggs, in which incubation was well advanced, was taken on June 17. The ground color of the eggs varies from cream or buff to almost pure white, spotted mainly about the large end with reddish brown and a few markings of obscure lilac. The average size of the specimens taken is 1.29x.92.

214. Sora.

Porzana carolina (Linn.).

The Sora was observed to be more numerous than the Virginia Rail in this locality. About the edge of almost every grassy slough or reed-grown pool, a pair or more of these birds had their nest. In situation and construction, the nest of the Sora is very similar to that of the Virginia Rail. It is generally placed in a tuft of tall grass, over five or six inches of water. Sometimes the nest is built in a clump of reeds, when the material used in its structure is largely reed-stems with a lining of grass. An average nest measures eight inches in outside diameter, four inches in inside diameter; outside depth five inches, and inside depth two and one-fourth inches. The rim of the nest slopes gradually on the inside so that the hollow is much the shape of a saucer. The base of the nest is about on the water level; and the top of the rim, five or six inches above the water.

Fresh eggs of the Sora Rail were taken as late as June 17. The earliest date on which eggs were observed is May 31. On June 18, a nest was found containing one young bird and eight eggs. The number of eggs constituting a set was found to be from eight to sixteen, the latter number being the largest observed in a nest.

221. American Coot.

Fulica americana Gmel.

The Mud-hen or Water-hen, as it is more commonly called in this region, was found in large numbers. There is hardly a slough of any size but is inhabited by one pair, or more, of these birds. At Water-hen Lake, they congregate by the thousands to build their nests and rear their young. The nests are frequently placed in very open situations. While passing along a trail, they are often observed floating on the surface of sloughs, moored among short, scattered grass-blades, and could be seen for a distance of several rods. At Water-hen Lake they were commonly built in the tall rushes growing about the border of the lake. The nests are composed of reeds and rushes, with a lining of the same material. The picture of a nest, taken at Water-hen Lake, is shown in Plate XLIII.

The first nest observed was found on May 23 and contained ten eggs, incubation just commenced. It measured seventeen inches, outside diameter, eight inches, inside diameter; six and one-half inches outside depth, three inches inside depth. It was moored among cattail rushes in a large slough close to a lake. The nesting period seems to extend over considerable time, as fresh eggs were taken as late as July 6, and, on August 4, a nest was found containing four eggs chipped and about to hatch.

From six to eleven eggs were found in a nest. Twenty eggs from this region average 1.93x1.33.

Frequently, when the nest of the Coot is approached, the parent bird may be seen to slip off into the water and sneak away through the rushes, uttering her single but oft repeated note, apparently to distract the attention of the intruder from the nest. When the Coot with a brood of young is suddenly come upon, she flutters along the water as though very severely wounded, in an attempt to allure you into pursuing her, that her chicks may escape. The eight or ten little chicks scatter and disappear among the rushes in a surprising manner.

224. Wilson's Phalarope.

Phalaropus tricolor (Vieill.).

This bird was seen in considerable numbers, generally in low meadows or in the neighborhood of sloughs or swampy places.

The only nest observed was found on May 27, when it contained only one egg. The bird flew from its nest, hidden by grass, almost at the feet of the investigator. When the place was visited one week later, June 4, the nest still held only one egg which was cold and apparently deserted.

The nest was situated on a slight rise of ground, partly surrounded by a grass-grown slough. A slight depression had been made and the egg rseted on the bare earth, there being no lining whatever. The nest was well hidden by the grass blades among which it was built and was difficult to discover.

The egg which the nest contained is of a brownish yellow, ground color, very thickly spotted all over the surface with dark brown. About the larger end there are numerous blotches, giving the eggs a very dark appearance. The egg is smaller than eggs of the same variety from Wisconsin, measuring only 1.15x .91. While the nest was being examined, the pair of Phalaropes could be seen swimming about in a slough close at hand. Apparently they were little disturbed by the intrusion.

230. Wilson's Snipe.

Gallinago delicata (Ord.).

The Jack Snipe was frequently seen feeding on the mud banks along Water-hen Lake, and about muddy pools. When flushed, it utters a sharp, almost startling, note and hastens to get out of gun range, using a method of flight sufficiently erratic to keep the best shot guessing.

A set of four eggs, thought to be those of Wilson's Snipe, were taken on June 5. These eggs were afterwards sent to the Smithsonian Institution at Washington, for identification, and it was decided that they were probably eggs of the Wilson's Snipe.

The nest was situated on the ground, at the base of, and partly hidden by, a bunch of grass. It was merely a depression in the earth with a lining of grass. The situation was on the low prairie, not far from water. When the nest was found, June 5, the eggs were fresh.

The ground color of the eggs is light brown with a greenish tinge. One of the four is more of a drab color. They are boldly marked with spots and blotches of dark reddish brown, with a very few spots and scratches of black. The blotches are

gathered about the larger end and in two of the eggs run together so as to entirely conceal the ground color. They bear a close resemblance to some eggs of the Black Tern. In shape they are pyriform, and measure as follows: 1:44x1.11; 1.47x 1.09; 1.48x1.07, and 1.48x1.10.

242. Least Sandpiper.

Tringa minutilla Vieill.

This little Sandpiper was not uncommon about the shores of the numerous lakes of the region. Many flocks, of from five or six to a dozen or more, were observed on the banks of Water-hen Lake. They are not timid, and allow one to come within a short distance of them. Often, they were seen feeding in company with other shore birds.

No nests of the Sandpiper were found. On July 12, however, along the gravelly, sloping shore of an arm of Lake Lenore, the shells of two broken eggs much resembling eggs of the Least Sandpiper were found. Several Least Sandpipers were seen near the place designated.

251. Hudsonian Godwit.

Limosa haemastica (Linn.).

Several pairs of Marbled Godwits make the muddy shores of Water-hen Lake, and the prairie about the lake, their summer home. They seem to prefer the low, mud shores of the lake and the neighboring pools, and here may often be seen feeding. Being large, they are conspicuous. The bill is very long and slightly upturned. The bill of one specimen from Water-hen Lake measured four and one-eighth inches in length.

No nest of the Godwit was found. A pair of birds, whose actions showed that they had a nest in the vicinity of a certain spot on the prairie, not far from a stream of water, were carefully watched, but the nest was not discovered. When the observer approached the place, on different occasions, one of the birds appeared on the scene, first, and flew about uttering a peculiar cry of warning; then the mate appeared, having apparently just left the nest, and the two birds continued to fly about and utter their cries while the observer remained in the neighborhood. On one occasion, the observer retired a little

distance from the place, and hid behind a clump of willows, hoping that the birds would settle. One of the birds, however, followed to the bush, flew about, and repeatedly dashed directly towards the observer, rising just in time to avoid the willows. The attempt to discover the nest was finally given up.

On July 14, a pair of Marbled Godwits and four nearly full-grown young were seen feeding on the shore of a muddy pool. Both a mature and a young bird were taken. The plumage of the young bird is markedly different from that of the mature bird. It is generally lighter colored, being marked on the wing by a white bar and, at the base of the tail, by a band of white.

By the middle of August the Godwits had formed flocks and, in company with other shore birds, were observed feeding on the mud flats about the outlet of Water-hen Lake.

273. Killdeer.

Aegialitis vocifera (Linn.).

This noisy Plover was everywhere abundant, generally being seen about the shore of a lake or other body of water. The bird is very wary and rarely, if ever, allows itself to be approached while on the nest. Therefore, it is rather difficult to discover the spot where the eggs are laid. Little attempt is made at nest-building; a slight depression in the earth, with perhaps a few blades of grass for a lining, serving as a nest. The place chosen is often a grass-covered knoll or rise of ground not far from water. One nest observed was merely a hollow in the sandy shore of an island, there being no lining whatever. Another nest was situated on a chip pile only a rod or so from a house. This nest contained young birds on July 20. On June 6, eggs were found almost ready to hatch. The number laid is generally four.

In shape the eggs are pyriform, quite pointed at the small end. Their color varies from dirty white to drab, more or less heavily marked with different shades of brown often verging almost into black. Their size is about 1.55x1.10.

298. Canada Grouse.

Dendragapus canadensis (Linn.).

The Canada Grouse, more commonly called Spruce Partridge in this region, was not observed. It is reported by the natives, however, as not uncommon in the spruce swamps north of Prince Albert, across the north branch of the Saskatchewan River, and is no doubt a resident.

300a. Canadian Ruffed Grouse.

Bonasa umbellus togata (Linn.).

The Canadian Ruffed Grouse is a rather common bird in the region visited. It was generally found in the strips of poplar bordering the Saskatchewan River, and in poplar bluffs. The drumming of the male was a familiar sound in the woods. One fallen log was observed which was frequently resorted to by one of the birds for this purpose, and the marks on a certain area of it gave evidence of long use.

The nest of this variety differs but little, if any, from the nest of the Ruffed Grouse.—*Bonasa umbellus*. It is a slight depression in the ground, beside a fallen tree or stump or in a brush pile. Leaves or bits of bark serve for a lining. One nest was situated at the base of a standing poplar tree. The hollow measured six inches in diameter and two inches in depth. It was thinly lined with dead leaves. The nest was only eight feet from the side of a trail by which one of the settlers passed daily. The parent bird did not leave the nest as it was passed, but sat always with her tail against the base of the tree, and sharply eyed the passer-by. On one occasion, she remained on the nest until approached within two feet. The nest was but little hidden, the remarkable resemblance of the bird, on the nest, to the surroundings, affording much protection.

On June 20, this nest contained nine eggs which were almost fresh. On May 7, a female of this species was shot and, on skinning, was found to contain a completely developed egg. On the following day, another bird of this variety was taken, which also held a fully developed egg and many others in different stages of development. On May 24, several broken eggs were observed lying on the sandy shore of a point running out into

Crooked Lake. The eggs had holes in their sides, large enough to admit a man's finger, and had been emptied of their contents, probably by some animal.

The eggs are of a rich cream color. Some sets are thinly spotted with brown. One egg, from the set of nine previously mentioned, has several large blotches of reddish brown on the surface. The average size of several eggs, taken from different nests, is 1.57x1.14.

308. Sharp-tailed Grouse.

Pediocaetes phasianellus (Linn.).

The Pin-tail Grouse or Prairie Hen was found to be a common bird in the more open prairie districts of the region under consideration. At the beginning of the nesting season, about the middle of May, it was a frequent occurrence to come upon seven or eight pairs of these birds, lined up for a courting or wedding dance. The manner in which the cocks strut back and forth before the hens is as amusing as it is undescribable.

The nest of the Sharp-tailed Grouse is situated on the prairie, at the foot of a tuft of dry grass or a low bunch of weeds. The slight hollow, which holds the eggs, is lined with dry grass. A favorite place seems to be that portion of the prairie which has not been burned over by the previous year's fires. Here, among the long, matted grass, the nest is well concealed. The bird is a close sitter and will frequently remain on the nest until one almost steps on her.

Many nests of eggs of this bird are destroyed annually by prairie fires. As early as May 12, a nest was found containing the scorched and blackened shells of eight or ten eggs; and many other nests which had been burned were found on later dates. The crows too, and some of the prairie animals, do much in the way of destroying eggs of this bird as well as eggs of the various prairie nesting ducks. Some of the birds, apparently, nest again after their first clutch is destroyed; for fresh eggs were taken as late as June 19. On July 31, two broods of young were seen, of which the first were but a few days old and the second almost full-grown. By the third week in August, many of the young birds had about attained their growth.

From eight to twelve eggs were found in a nest, but it is reported that as many as fifteen are sometimes laid. They are

greenish or olive brown in color; minutely, but often thickly, speckled over the entire shell with brown of a reddish or darker shade. Several specimens taken in the Saskatchewan River region average 1.70x1.30.

325. Turkey Vulture.

Cathartes aura (Linn.).

Occasional individuals of this bird were seen sailing about high in air, scanning the surrounding country. One specimen was seen which had been caught in a trap. No nests were found but, doubtless, a few pairs nest in this region as they were seen at different times throughout the spring and summer.

331. Marsh Hawk.

Circus hudsonius (Linn.).

The Marsh Hawk is one of the most numerous of the hawks in this region. Its favorite haunts are in the neighborhood of swamps and sloughs and the marshy parts of the prairie where there is a scattered growth of low bushes. About such places it may be seen for hours at a time, sailing back and forth near the ground in its search for small quadrupeds and other morsels of food. No nests of this bird were discovered. The picture of a wounded Marsh Hawk is shown in Plate XLI.

337a. Krider's Hawk.

Buteo borealis kriderii Hoopes.

Note.—Krider's Hawk was usually observed in the vicinity of bodies of water. When seen on the prairie, it was generally in the neighborhood of sloughs.

For a nesting site, this Hawk selects one of the taller trees in a poplar bluff, or occasionally a tree standing almost alone on the prairie is chosen. In the case of a dozen or more nests observed, the site was close to a body of water. Several nests were built in small bluffs on the edge of sloughs. Two nests were placed near the top of tall trees growing only a few feet from the shore of Crooked Lake, and could be seen from the lake, at a distance of a mile or more. Another nest was built in a poplar standing

on the sloping bank of the Saskatchewan River, while still another was perched on the very top of a poplar stub, on an island in the same river. The stub holding the last nest had no limbs whatever, the nest resting on the upper part of the stub where the tree-trunk had broken. Most of the nests were situated at a height of from thirty to forty feet from the ground. One was forty-five feet up, while another was only fifteen feet from the ground. The nest is large, measuring from thirty to thirty-six inches, outside diameter, and from eighteen to twenty-four inches outside depth. The depression which holds the eggs is shallow, several nests showing measurements of from seven to ten inches diameter, inside; and from three to three and three-fourths inches depth, inside. The materials used in the construction of the nests observed were, mainly, sticks and twigs, with occasional pieces of bark, sod or a few leaves. The hollow is lined with shreds and bits of bark, a few small twigs and sometimes a little grass. Most of the nests had a few twigs of poplar with buds or green leaves scattered about the rim of the nest.

In this region the eggs are laid during the first week or two of May. Several sets taken the last week of May were far advanced in incubation. On May 27, a nest was found containing two, yellowish, downy young, two or three days old. Two seems to be the number of eggs most commonly laid, for, of the ten nests observed, seven contained two eggs, one contained two young birds, and the remaining two contained one egg each. The two single eggs were far advanced in incubation.

The eggs of Krider's Hawk vary greatly in appearance. The ground color is a pale bluish-white. Some of the eggs are entirely unmarked, while on others the shell is so crowded with splashes and blotches as to almost obscure the ground color. Eggs range all the way between these extremes, though the majority seem to be not heavily marked. The markings are generally some shade of brown. Some of the specimens are rather evenly spotted, while others look as though the color had been unevenly daubed on with a brush. On some of the eggs the markings are clouded and splashed. Even in the same set, the eggs frequently differ widely. One may be entirely unmarked, and the other spotted and streaked; or, one may be much more heavily marked than the other, the markings in one, perhaps, clustering about the smaller end and in the other about the larger. A few specimens show faint markings of light

brown and purple. The average size of thirteen eggs from Saskatchewan, N. W. T., is 2.33x1.82. The smallest measure, 2.17x1.77; the largest, 2.46x1.85.

Several times as the observer approached a nest, the Hawk was seen standing half upright on the nest, watching the intruder. The bird always left the nest before the tree was reached, generally soon enough to be out of gun range. Commonly, on leaving the nest the bird was joined by her mate and the two circled about at a safe distance uttering, at frequent intervals, their piercing, whistle-like cries of alarm.

348. Ferruginous Rough-Leg.

Archibuteo ferrugineus (Licht.).

On May 5, a pair of these birds was found to have a nest along the bank of the Saskatchewan River near Saskatoon, Sask. The nest was situated in the fork of a large birch tree, at a distance of forty feet from the ground. The tree stood only five or six feet from the water's edge. Large sticks, pieces of driftwood, twigs and bark were the principal materials used in the construction of the nest. The lining consisted of small twigs, strips of bark, pieces of turf, grass, and three large black feathers. A squirrel's head, on the edge of the nest, gave evidence that the birds had not gone hungry. This nest was considerably larger than any nest of Krider's Hawk observed. It measured forty inches outside diameter, twelve inches inside diameter, twenty inches outside depth, four inches inside depth.

When the observer approached the nest, both birds flew from it, one of them leaving the place, the other remaining for some time, flying about or quietly perched in a tree close at hand, watching the intruder's every move.

The three handsome eggs which the nest held were very slightly incubated. Their ground color is bluish white, but they differ widely in marking. The first one is quite sparingly marked with spots, small, with the exception of two or three, of a light chocolate brown. The second egg is heavily marked with large and small spots and, about the larger end, bold blotches of dark reddish brown. This is the most striking and handsome egg of the set. The third egg is a sort of "go-between," of the other two. A great number of reddish brown spots and specks are evenly scattered over the whole surface. Most of them are so minute,

however, that the eggs has not the appearance of being heavily marked. Only a few obscure marks of purple show on the first two eggs, while on the third they are very numerous. Thus we have, from the same set, three eggs which, at first sight, show little if any resemblance to each other. The eggs measure respectively, 2.50x 2.00; 2.44x1.98; 2.46x1.97.

352. Bald Eagle.

Haliaeetus leucocephalus (Linn.).

The Bald Eagle does not inhabit this region in great numbers. The few individuals observed were seen about rivers or lakes. In May 29, a nest of this bird was observed at Middle Lake. It was situated on the top of a tall poplar stub, on a wooded island in the lake, and could be seen at a distance of two miles or more. The nest was an immense structure made of large branches, pieces of drift-wood, and bark. It was practically impossible to reach the nest as the stub on which it was built was decayed, and so small, for some distance below the nest, that it seemed a very poor support for so large a nest.

On the ground, about the foot of the stub, was a great mass of half-decayed branches and sticks which had apparently been accumulating for many years.

The birds retreated to a safe distance when the nest was approached, but their actions seemed to show that there were young birds in the nest.

360. American Sparrow Hawk.

Falco sparverius Linn.

The little Sparrow Hawk is very common in this region. It is quite fearless and frequently makes its abode in close proximity to the habitation of man. Often, as one passes along the railroad, one or more of these birds may be seen flying low over the prairie in search of food, or, occasionally, alighting on the telegraph poles or wires. On the wing, they are easy and graceful, and expert in catching their food which consists mainly of insects and small rodents.

On the open prairie the Sparrow Hawk resorts to the scattering strips of timber along water courses. For a nesting site, the bird selects some hollow in a tree or dead stub. Frequently

the deserted nest of a Woodpecker is taken. Sometimes, when there is a scarcity of suitable trees, a cavity in a telegraph pole is made to serve the purpose. There is no lining to the nest unless the bottom of the cavity happens to be covered with bits of wood. One nest observed was situated in a dead stub standing in a strip of small timber bordering a creek. The cavity had, apparently, been made by a Woodpecker. It was about two and one-half feet deep and contained four fresh eggs on June 6. The ground color of the eggs is creamy white, marked with numerous small dots, spots and splashes of chestnut brown. The eggs measure about 1.35x1.11.

367. Short-Eared Owl.

Asio accipitrinus (Pall.).

Only one or two of these birds were seen and no nests were found. One of the inhabitants of the region stated that he had seen several nests of the bird in the past two or three years. They were situated on the ground, generally on the low, marshy prairie where there was a scattering growth of bush willows.

375a. Western Horned Owl.

Bubo virginianus subarcticus (Hoy).

Two young Horned Owls about two-thirds grown, were found May 30, perched on a rude platform of sticks which was apparently the remains of the nest. The tree which held the nest was in a growth of poplars near the edge of Basin Lake. The height at which the nest was built was about twenty-five feet.

The parent Owls were not far off and made their appearance when the observer approached the young birds. They alighted on trees close at hand and expressed their disapproval of the intrusion by sharply snapping their beaks. The observer had partly ascended the tree, in order to get one of the young owls, when he was very forcibly surprised by a sharp blow on the head. Turning quickly, he saw that one of the old Owls was the offender. The bird made repeated dashes but did not repeat its first act, preferring to keep out of reach of a branch which the intruder had broken off for self-protection.

376. Snowy Owl.

Nyctea nyctea (Linn.).

A pair of Snowy Owls was seen at Saskatoon on May 4, and 5. They were found in a rather dense fringe of timber on the bank of the Saskatchewan River. A careful search was made but no nest containing eggs or young was found, although there was a rather large nest of sticks in the vicinity which appeared to have had recent use and, possibly, had belonged to these birds. The birds were rather wild and would not allow one to come within gun shot of them.

388. Black-billed Cuckoo.

Coccyzus erythrophthalmus (Wils.).

A bird seen on August 2 was probably a Black-billed Cuckoo but identity was not positive. No specimen of this species was taken.

390. Belted Kingfisher.

Ceryle alcyon (Linn.).

The Kingfisher was occasionally seen along streams of water or the borders of lakes, often perched on a dead limb overhanging the water. From this vantage point, the bird darts into the water after its meal of fish. The head and bill of the bird are strikingly large in comparison with the size of its body.

At Basin Lake a Kingfisher was seen about a freshly excavated hole in a high bank on the lake shore. This was on May 30; and, as the excavation seemed to have been just completed, it is probable that the complement of eggs had not been laid.

393a. Northern Hairy Woodpecker.

Dryobates villosus leucomelas (Bodd).

This bird was frequently seen, generally in poplar bluffs, searching the trees and stubs for insects. One was sometimes seen about the wood-yard and stable at the home of one of the inhabitants. Although no nests were found, it doubtless breeds in this region, for it was observed throughout the spring and summer.

402. Yellow-Bellied Sapsucker.

Sphyrapicus varius (Linn.).

A few specimens of this bird were observed. No nest was found, though it doubtless breeds.

405. Pileated Woodpecker.

Ceophloeus pileatus (Linn.).

The Pileated Woodpecker, or Logcock, is occasionally met with in the more densely-wooded district north of Prince Albert, across the north branch of the Saskatchewan. It was not seen in the scattered timber south of Prince Albert.

412. Flicker.

Colaptes auratus (Linn.).

The Flicker was found to be a common bird. It was particularly so about Prince Albert, in the timber along the Saskatchewan River. Many were also seen in the poplar bluffs scattered over the prairie south of Prince Albert.

The nest is an excavation in a dead or partly dead, tree-trunk. There is no lining unless it be a few bits of wood left in the cavity after excavation. The same cavity is often used several successive years. The height at which the cavity is made varies greatly, some being as high as forty or fifty feet, while others are not more than eight feet from the ground.

In this region, the bird begins to lay, generally, by the first of June. The number of eggs in a set varies considerably, from five to nine being the usual number. More than that, however, are sometimes laid.

420. Nighthawk.

Chordeiles virginianus (Gmel.).

This bird is also common in this region. Through the day it usually resorts to the cover of woods and may sometimes be seen resting flat on the horizontal limb of a tree. About evening, or on cloudy days, it spends its time flying through the air in pursuit of insects. They often hunt in companies of half a dozen or

more, and their peculiar cries, uttered while sailing through the air, are frequently heard. Occasionally one will swoop down towards the earth and rise up again, describing in its course an arc of a circle. The peculiar booming sound which is heard seems to come from the wings.

The Nighthawk builds no nest, but lays its two eggs on the bare ground,—sometimes on the open prairie and sometimes in the edge of woods.

428. Ruby-Throated Hummingbird.

Trochilus colubris (Linn.).

A pair of these birds was seen at Crooked Lake and another pair was seen at different times near Water-hen Lake. No nest was found.

444. Kingbird.

Tyrannus tyrannus (Linn.).

The Kingbird was very common especially in the low prairie districts where there are numerous sloughs surrounded by a fringe of bush willows. In such localities there is an abundance of insect food and this, no doubt, is a great attraction for this flycatcher.

The nest is built in trees or bushes, not far from the ground. A nest found on June 27 was situated in a willow bush growing in the edge of a slough where the water was a foot deep. The nest was fastened to the twigs, which were woven into the walls of the structure. The height of the nest above water was four feet. The nest measured four and one-half inches outside diameter, three inches inside diameter, four and one-fourth inches outside depth and two inches inside depth. It was closely woven of grasses with a lining of finer grasses and a little down from the willows.

Three eggs, taken from the nest described, measure .70x.90; .69x90; .71x93.

456. Phoebe.

Sayornis phoebe (Lath.).

The Phoebe was occasionally seen. On May 21, a nest was found in a shed on the bank of the South branch of the Saskatchewan at St. Louis crossing. The nest was built on a cross-beam and composed of mud and grass, lined with grass and hair. The three eggs which the nest contained were fresh.

474a. Pallid Horned Lark.

Octocoris alpestris leucolaema (Coues).

This bird was very common in the prairie portion of the region. It is an early nester, the set of eggs often being completed before the snow has melted and left the ground entirely bare. A nest found on May 16, contained four good sized young. It was openly situated on a grassy slope. The top of the nest was just a little above the surface of the surrounding earth. The cup-shaped hollow was thinly lined with grass stems. A nest found May 27 was sunk into the ground at the base of a bunch of grass, on a gradual slope close to the shore of a small lake. The depression was substantially lined with grass. There were also a few bits of downy vegetable material in the lining. The measurements of the nest are as follows: diameter, outside, three and one-half inches; inside, two and three-eighths inches; depth, outside, two and one-half inches, inside, one and three-fourths inches. The nest contained three eggs so far advanced in incubation that it was impossible to preserve them. In appearance they differed little, if any, from the better known variety,—the Prairie Horned Lark.

484. Canada Jay.

Perisoreus canadensis (Linn.).

The Whiskey Jack, as the bird is called, is reported as common in the spruce timber north of Prince Albert. They occasionally hang about the lumber camps and feast on the leavings from the table. This bird was not observed south of Prince Albert.

488. American Crow.

Corvus americanus Aud.

This black robber was always in evidence. It was a common sight to see eggs of the various water birds, emptied of their contents and scattered along the edge of a slough or lake. In one case a pair of Crows had built their nest on an island, close to the edge of which a colony of Holboell's Grebes were nesting. The number of egg shells scattered about gave evidence of the work of the Crows.

The nest of the Crow was frequently found built in one of the trees of a poplar bluff or in tall willows. The situation was generally not more than ten or fifteen feet from the ground. Several nests were built in scrubby clumps of trees growing in pools of water, the nests being situated in the branches nine or ten feet above the water. A nest found at Saskatoon, N. W. T., on May 3, contained four fresh eggs. The tree in which the nest was built was growing on the steep, wooded bank of the Saskatchewan River. The nest was situated in the crotch of a poplar, at a height of eleven feet. It was composed of sticks, twigs, rootlets and binding twine, lined with strips of bark, binding twine, grass and a large amount of hair. The bird remained on the nest, as is usually the case, until the tree was struck with a stick. One nest observed was lined almost entirely with cow's hair which had been taken from a dead cow lying on the prairie near the poplar bluff in which the nest was situated. It certainly did make a cosy nest. The site chosen by the pair of birds spoken of as nesting near the colony of Grebes was rather novel. The island on which the nest was built was low and, at one end of it, a large number of overturned stumps and small logs were strewn over the ground. One of the stumps stood upright, propped up by its roots, and under this crude arch the Crows had built their nest.

Several nests were found from May 3 to May 19, and in most cases the eggs—four or five in number—were either fresh or slightly incubated.

494. Bobolink.

Dolichonyx oryzivorus (Linn.).

This beautiful songster was frequently seen and heard about the meadow lands and prairie. The plain brown dress of the female contrasts so strongly with the brilliant attire of the male that, for one not acquainted with the Bobolink, it is hard to believe they are the same species.

One pair of birds was watched at differnet times, but the whereabouts of their carefully hidden nest was never revealed.

495. Cowbird.

Molothrus ater (Bodd.).

The Cowbird was found in large numbers. Flocks were often seen about cattle or horses and some of the birds were invariably perched on the backs of the animals; both parties, apparently, being contented with the arrangement.

The Cowbird builds no nest but lays its eggs in other birds' nests. Eggs of this tramp were found in nests of the Vireo and some of the Sparrows. One or two eggs are found in a nest. Two eggs, found in a nest with three pretty eggs of the Vireo, looked very much out of place.

After the breeding season, the Cowbirds were seen in large flocks feeding in the fields and on the prairie.

497. Yellow-Headed Blackbird.

Xanthocephalus xanthocephalus (Bonap.).

This handsome bird, although not as common as the next species, the Red-wing, was found in considerable numbers. The small grass-grown sloughs do not seem to suit the tastes of the Yellow-head and he is not commonly found here where the Red-wing is always present. He seems to prefer the large sloughs, especially those which have tall reeds or cat-tail rushes growing in them, and the lakes which are bordered with a growth of rushes. In such places the male in his gaudy attire of bright yellow and black may be seen, balanced on a swaying reed and uttering, at intervals, his harsh, grating note. The female, more modestly

attired, is probably not far away, engaged in her domestic duties.

The nest of the Yellow-headed Blackbird is a well built, cup-shaped affair fastened to several closely growing rushes at a height of from six to fourteen inches above the water. It is closely woven of grass and narrow strips of rushes. The wall is thick and the hollow deep. Many nests observed were lined with broad grass blades or strips of rushes which gave the interior of the nest a rather bright yellow color while the exterior was the color of the dry grass. These nests were particularly attractive. The Yellow-heads usually nest in colonies, sometimes of only five or six pairs, but ordinarily of much greater extent. Tall, thickly growing rushes of a slough or shallow, marshy lake afford a suitable location for a colony.

The number of eggs laid is three, four or five; the usual nest complement, however, is four. The eggs show little or no resemblance to the eggs of most Blackbirds. The ground color is light gray and the whole surface is quite thickly covered with spots of brown and umber. In an occasional specimen the markings have gathered in a wreath about one end. The ground color in some specimens is of a greenish shade. Their size is about 1.05x.72.

498. Red-Winged Blackbird.

Agelaius phoeniceus fortis (Linn.).

This noisy denizen of the marshes was everywhere abundant. Not as hard to suit as the previous species, the Yellow-head, it was found on the borders of almost every slough and marshy lake. Often the two species nest in close proximity. When a nest is approached while the female is sitting, the bird hurries off just before you get within reach, and her cries soon bring the male to the spot. The pair circle about and give evidence of their disapproval of the intrusion, in a very noisy fashion.

The nest is similar to that of the Yellow-headed Blackbird but not as attractive by far. It is more rounded and less deeply hollowed. The lining of broad, yellowish strips found in the Yellow-head's nest is not present, finer grasses being used. The situation chosen may be a clump of rushes, a bunch of tall grass or, sometimes, a low bush on the edge of a slough. One nest observed was built in a willow, eight feet from the ground.

The eggs, three to five in number, are very different from those of the preceding species. In color they are light blue, variously spotted and streaked with purple and black. The size is about 1.04x.75. Nests containing eggs were observed from the last week in May to June 17.

501b. Western Meadowlark.

Sturnella magna neglecta (Aud.).

The Western Meadowlark was ever present in the low prairie tracts. The bird seems to delight in perching on a fence or more elevated stand, as a telegraph wire, and giving its clear, whistling note.

The nest of the Western Meadowlark is rather hard to discover, so carefully is it hidden in the long grass; but the bird is a close sitter and frequently reveals the situation of her treasures by flying from the nest almost at your feet. It is generally situated at the base of a bunch of grass and, frequently, some of the grass blades are so bent over as to form a more or less complete covering or dome. The nest is not a bulky, thick-walled affair but is rather frail, the walls being closely woven of grass blades. It is occasionally sunk into a slight depression at the side of a hummock.

The eggs are five or six in number. A nest found on May 17 contained six eggs in which incubation had commenced. The color of the eggs is white, thickly spotted with different shades of reddish-brown and purple. The spots are, with the exception of a few, quite small and scattered over the whole surface but rather more thickly about the larger end. The six eggs measure, respectively, 1.10x.85; 1.15x.86; 1.15x.85; 1.16x.82, 1.17x.87 and 1.16x88 inches.

511b. Bronzed Grackle.

Quiscalus quiscula aeneus (Ridgw.).

The Crow Blackbird, as the Grackle is commonly called, was found in large numbers. About the numerous sloughs fringed with willows the hoarse note of the Grackle could be heard mingling with the shriller notes of the Red-wing. The birds frequently nest in colonies, the low scrubby trees and bushes on

the edge of sloughs serving the purpose of nesting sites. The nest is a bulky, rather rough looking affair composed of weeds and grass, frequently with a layer of mud in the walls. The hollow is lined with finer grasses. The Grackle is an early nester. A nest observed June 17, near Water-hen Lake, held four young birds almost large enough to leave the nest.

529. American Goldfinch.

Astragalinus tristis (Linn.).

The bright-colored little Goldfinch, or Wild Canary as it is often called, was occasionally seen during the summer but no nests were found.

534. Snowflake.

Passerina nivalis (Linn.).

Several small flocks of Snow Birds were observed during the first two weeks of May. Specimens were taken on May 8, and 13, but none were seen after the 13th of May, they having departed for their northern home. The specimens taken were not in the pure white dress, the upper parts and wings being marked with brown and blackish.

538. Chestnut-collared Longspur.

Calcarius ornatus (Towns.).

Three birds which were probably Longspurs were seen, but not positively identified. No nests were found.

558. White-throated Sparrow.

Zonotrichia albicollis (Gmel.).

The clear, whistling note of this bird was often heard ringing through the woods. This Sparrow is a common bird in the more wooded portions. It was frequently observed quietly scratching away on the ground beneath the underbrush, searching for food. The note is usually given when the bird is high up in a tree. These birds are seen throughout the summer and, though no nests were found, doubtless breed in this locality.

560. Chipping Sparrow.

Spizella socialis (Wils.).

The Chipping Sparrow was occasionally observed, generally not far from shrubbery or bushes. On May 21 one of these birds was seen building a nest. The site chosen was a low bush in a grove of scattered timber. The nest, about half completed, was made of grass, the usual lining of hair not yet having been added. No nest containing eggs was found.

561. Clay-colored Sparrow.

Spizella pallida (Swains.).

The Clay-colored Sparrow is a common bird in the region visited. Its favorite haunts seem to be the portions of prairie where there are numerous, low willows and bushes growing in scattered clumps. In such localities the nest may be found. It is situated on the ground at the base of a tuft of the long, dry grass of the previous year. Occasionally it is built in the matted grass at the foot of a small bush. The nests observed were not sunk into the earth but were built on the surface. The body of the nest is composed of comparatively coarse grass stems, while the cavity—which is deeply cupped and rounded—is lined with very fine grasses and a small amount of hair. The walls of the nest bend inward near the top, thus making the inside diameter less at the top than it is farther down in the cavity. One nest, which was built at the foot of a bush and closely hidden in the grass, is rather peculiar in that on one side the wall bends in over the hollow, forming quite an arch. Of the nests examined, the cavities vary but little in size, measuring very close to two inches in diameter and one and one-half inches in depth. In outside measurements, however, the nests differ considerably, some being much bulkier than others. Generally the nest is considerably longer in one diameter. Two specimens measure, respectively: two and three-fourths by three and one-half inches; and three by four and one-half inches, in outside diameters, the first one being near the average size. The outside depth of the nest is, in specimens measured, about two inches. On the whole, the nest of this bird is an attractive and cozy little structure. So securely hidden are they in the grass

that they can be found only by flushing the bird. In some cases when the bird was scared from the nest, almost under the feet of the observer, a continued search was necessary to find the spot where the nest was situated. The bird usually left the vicinity of the nest when disturbed, but on two occasions returned at the expiration of fifteen or twenty minutes time.

The eggs of the Clay-colored Sparrow are a pretty light blue, in color, not thickly spotted with dull, reddish brown, some of the spots being almost black. The markings are gathered mainly about the larger end. Eggs taken, vary in size from .65x.51 to .73x.54. The number of eggs found in a nest was four or five, most of the nests containing the latter number, five. Fresh eggs were found the last week of May and the first two weeks of June.

567. Slate-colored Junco.

Junco hyemalis (Linn.).

This bird was frequently seen near Prince Albert in the timber along the Saskatchewan River. On June 12, a nest containing three young birds and an addled egg was found, the bird revealing its position by flying off when approached. The locality was a low, swampy tract covered with spruce timber, and the roots and vegetation seemed to be the only support for the feet. The nest was almost hidden from view by the long, dry grass covering a slight mound on which the nest was situated. The little birds were several days old and it is surprising that the addled egg had not been broken or thrown from the nest by the parent. The egg is white, marked with spots and specks of reddish brown, particularly numerous about the larger end where they form a wreath. It measures .70x.53.

581. Song Sparrow.

Cinerea melodia (Wils.).

The Song Sparrow is a common bird in this region. The nests found were built on the ground, hidden in the long, dry prairie grass or at the base of a bush. One was situated close beside a log; another was almost covered over by an arch of grass. The last nest contained young birds about half-grown,

on June 17. The material used in the construction of the nest is coarse grass with a lining of finer grass.

584. Swamp Sparrow.

Melospiza georgiana (Lath.).

On May 26, a nest and five eggs, thought to belong to this bird, were found but the identification was not satisfactory. Eggs from the set were sent to the Smithsonian Institution, however, and it was decided that they were probably eggs of the Swamp Sparrow.

The nest was situated on the ground, hidden in a clump of grass. Low prairie, not far from the border of a slough, was the locality chosen. The body of the nest is composed of coarse grass-stems and sticks, while the lining consists entirely of very fine grasses, the branching ends of which show them to be the tops. Although sunk a little way into the earth, the nest is substantially built and is compact.

The hollow is well rounded and rather deep. The measurements of the nest are: inside depth, one and three-eighths inches; inside diameter, two and one-fourth inches; outside depth, two and one-fourth inches; outside diameter, three and one-fourth by four inches.

When the eggs were found, May 26, incubation had not commenced. In color they are of a light bluish tint rather thickly spotted with reddish brown and a few obscure markings of purple. The eggs are much more heavily marked at the larger end and, on three of the specimens, the spots so near together as to entirely cover the bluish ground-color. The spots are clouded, not clear and distinct. The five eggs measure: .75x.54; .75x .54; .74x.54; .74x.54; .75x56.

595. Rose-breasted Grosbeak.

Zamelodia ludoviciana (Linn.).

This rather handsome bird, though not at all common, was occasionally seen. Two individuals were observed about the border of a lake surrounded by timber. No nests were found.

611. Purple Martin.

Progne subis (Linn.).

In this region the Martin still follows its primitive custom in the selection of a nesting site. The settlers are so few that bird houses and suitable nooks about buildings are practically wanting and the hollows of trees are made to answer for nesting purposes. The majority of the cavities are probably made by Woodpeckers, originally, and when deserted fall to the Martin or to the Tree Swallows. Many nests of the Martin were found in dead stubs standing in timber bordering a lake. At Basin Lake, where much of the shore is bordered by the standing trunks of dead trees, the Martins were especially numerous. Some of the nests were in trees which stood in several feet of water. The nest cavity was usually lined with such materials as twigs, leaves and grass. One nest was situated in a tree standing only a few feet from a tree in which there was a nest of Krider's Hawk. Both nests were occupied but the Hawks seemed to pay little or no attention to their near neighbors.

612. Cliff Swallow.

Petrochelidon lunifrons (Say,).

Two colonies of the Cliff or Eave Swallows were seen. The odd nests, made entirely of mud by the little plasterers, were arranged in rows under the eaves of buildings. Many of the nests were so close to each other that they joined, only the double wall intervening. At one house the nests had just been torn down and the Swallows seemed to be in great dismay. Many were flying about in the air while others were clinging to the wall where the nests had been, apparently making a very close examination. These birds were aided in keeping this position on the face of the building by bracing their tails against the wall. No nests were disturbed.

614. Tree Swallow.

Tachycineta bicolor (Vieill.).

The little White-bellied Swallow was frequently observed often in company with the Purple Martin. The nests were

quite similar in situation to those of that bird,—a hollow in a stub or tree-trunk usually serving the purpose. Sometimes the nests are built in a hollow at the top of a stump standing partly in water. The hollow is lined with a thick bed of feathers on which the crystal white eggs rest. In number they range from five to eight or nine. Nests containing eggs were found the last of May and after the middle of June. Large numbers of these birds were often seen skimming along just above the rushes of sloughs or marshy lakes, searching for their insect food.

619. Cedar Waxwing.

Ampelis cedrorum (Vieill.).

Several of these birds were seen in a strip of small scrubby timber on the edge of a lake, but no nests were found. As they were seen here both in June and July, there is no doubt but that they were nesting.

622a. White-rumped Shrike.

Lanius ludovicianus excubitorides (Swains.)

The favorite haunt of the Butcher-bird, as the Shrike is often called, is a portion of the prairie where there is an abundance of low, scrubby trees and shrubbery. It was observed, however, scattered over the region generally. The nest is situated in a bush or in the thick branches of a tree not far from the ground. It is a bulky structure, the materials comprising it being twigs, grass, weeds and rubbish in general, with a thick lining of feathers. On May 21, a nest was found, apparently completed, but it contained no eggs. It was built in a bush-willow near a trail. On July 3 a pair of Shrikes were seen feeding four young which had left the nest but were not quite able to fly.

624. Red-eyed Vireo.

Vireo olivaceous (Linn.).

On June 17, a nest was found and a Vireo slipped off and flew away when closely approached. Although it was probably a Red-eyed Vireo, it is not certain as the bird was not secured. The nest was a beautiful little cup-shaped structure woven of

vegetable fibers, fine shreds of bark and small grasses, and suspended from the fork of a small branch about six feet from the ground. The nest contained three eggs of the Vireo, pure white, finely spotted with reddish brown, and two eggs of the Cow-bird. When the nest was visited a week after it was found, only a small part of the rim still remained clinging to the fork. The nest, eggs and bird had disappeared.

704. Catbird.

Galeoscoptes carolinensis (Linn.).

The Catbird was occasionally seen, usually in shrubbery or bush-willows bordering a slough. No nests came under observation.

705. Brown Thrasher.

Harporhynchus rufus (Linn.).

Several of these birds were seen at different times during the summer. No careful search was made for their nests and none were found.

721b. Western House Wren.

Troglodytes aedon aztecus Baird.

This lively little bird is rather common in this region. Its nest may be found tucked away in a great variety of places, generally in nooks and corners about buildings. One found on May 21 was built under the cornice of a building. It was complete, apparently, but contained no eggs. Another nest, observed late in July, was built in the crevice between the logs of an unfinished cabin. This nest contained young birds about half grown.

725. Long-billed Marsh Wren.

Cistothorus palustris (Wils.).

About the larger sloughs and shallow, rush-grown lakes this noisy little Marsh Wren makes its home. Perched on a bended reed with its tail standing nearly straight up, it presents a very

amusing appearance. These birds are peculiar in their nesting habits in that one pair of birds construct five or six nests and use only one. These nests are located in close proximity to each other anl resemble each other in every respect except that the one containing the eggs is the only one lined. The nest is an almost round, hollow ball, closely woven of dry grass, with a little willow-down intermingled. The hollow is usually lined with willow-down. Grass or rushes growing in water are woven into the sides of the nest and support it a few inches above the water of the marsh or slough. One nest measured four and three-fourths inches outside diameter, and six inches outside depth. The entrance, so small as to almost escape observation, was situated in the side considerably nearer the top than the bottom.

On June 20 a nest containing six eggs slightly incubated was found. The eggs are heavily marked over the entire surface with chocolate brown, giving them a very dark appearance. Eggs measure: .63x.50; .66x.51; and, .67x.51.

761. American Robin.

Merula migratoria (Linn.).

Though not as common as farther south, the Robin is present in considerable numbers. The first nest was found on May 19, and contained one egg. It was built in a willow only two feet from the ground.

Nothing of special interest was noted in regard to its habits.

English Sparrow.

Passer domesticus (Linn.).

This little pest has wandered to the Saskatchewan region, but does not yet exist in such large numbers as to be the nuisance that it is farther south.

VARIATIONS IN THE DISTRIBUTION OF THE BILE DUCT OF THE CAT (*Felis domesticus*).

W. S. MILLER, M. D.

Associate Professor of Anatomy, University of Wisconsin.

MATERIAL.

The results of the following investigation are based on a study of one hundred animals which were obtained for use in the Comparative Anatomy Laboratory of the University of Wisconsin. It is highly improbable that there was any close relationship between the different individuals for they came from all parts of the city of Madison and the surrounding country. All the animals were full grown. No record was kept in regard to sex or sex variations.

NOMENCLATURE.

Lobes:—The liver of the cat is divided by the *Ligamentum falciforme hepatis* into a right and left half; each half is further subdivided into secondary portions termed lobes. The number and names of the various lobes differ according to the author one may be reading.

In accordance with the results of this study the liver of the cat is subdivided into six lobes, viz., *quadrate, right median, right lateral, left median, left lateral* and *caudate* (Fig. 1). I have named the median division of the right lateral "quadrate" because, as will be seen, its ducts have a separate distribution from that of the lateral division and because it is homologous with the quadrate lobe of the human liver. I have also considered the cranial and caudal divisions of the right lateral lobe as divisions, rather than separate lobes, because their ducts usually unite and because there is always present more or less fusion of the two divisions.

Ducts:—For the purpose of analysis the following nomenclature of the ducts is made use of, viz., *ducti hepatici, ductus hepaticus dexter, ductus hepaticus sinister, ductus hepaticus proprius, ductus cysticus, ductus choledochus* (Fig. 2).

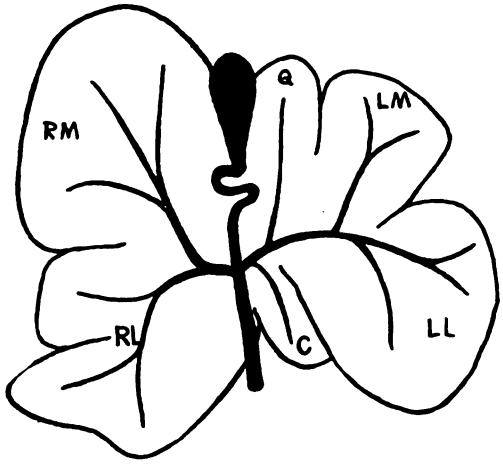

FIG. 1.—Case No. 62. The distribution of the ducts is typical. R. M., Right median lobe; R. L., Right lateral lobe; C., Caudate lobe; L. L., Left lateral lobe; L. M., Left median lobe; Q., Quadrate lobe.

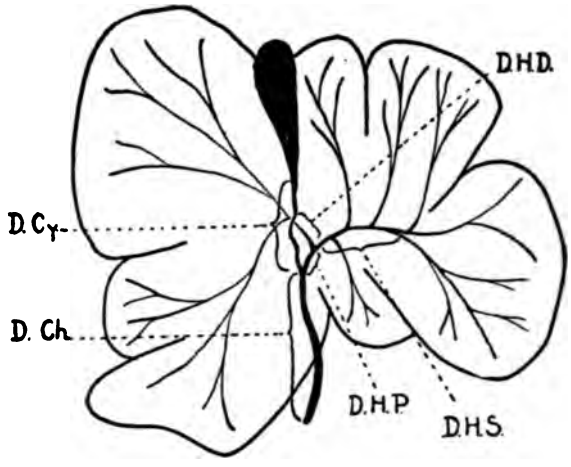

FIG. 2.—Case No. 33. A ductus hepaticus proprius is present. D. H. D., Ductus hepaticus dexter; D. H. S., Ductus hepaticus sinister; D. H. P., *Ductus hepaticus proprius*; D. Cy., Ductus cysticus; D. Ch., Ductus choledochus.

Ducts from the lobes of the liver to the ductus cysticus or to the ductus choledochus are called *ducti hepatici.*

A duct formed by branches coming from the right median and right lateral lobe is called the *ductus hepaticus dexter.*

A duct formed by branches coming from the left median and the left lateral lobe is called the *ductus hepaticus sinister.*

The ductus hepaticus dexter et sinister may continue as separate ducts and join either the ductus cysticus or the ductus choledochus. If, however, they should unite into a single duct, the resulting duct is called the *ductus hepaticus proprius.*

The *ductus choledochus* is considered as beginning at the point of entrance of the ductus hepaticus dexter et sinister. If either of these ducts enters below the other, then the ductus choledochus is considered as beginning at the point of entrance of the lower duct.

The duct leading out of the *vesica fellea* is called the *ductus cysticus.*

METHOD OF STUDY.

After the ductus choledochus and the ducti hepatici had been exposed by a careful dissection the bile (fel) was expressed from the vesica fellea and the exposed ducti hepatici by direct pressure with the finger. The duodenum was next opened, its surface washed clean and the cannula of a syringe filled with a vermilion starch injecting mass was inserted into the orifice of the ductus choledochus and the injection was continued until the ducts were well filled with the mass.

Each liver was carefully dissected and a drawing of each dissection was made upon a standard diagram of the lobes of the liver. The very small anastomoses which were occasionally seen (Pl. XLIX, Fig. 1) were ignored in the analysis. When two or more ducts were found leaving one lobe for different destinations, each destination was recorded. (See ducts from quadrate lobe in Plate XLIX, Fig. 2.) If, however, two or more ducts from one lobe had the same destination, they were recorded as one. (See in text, Fig. 2, the ducts from the left median lobe.) In general a smaller duct was said to join a larger, but in one case an arbitrary ruling had to be made. The ducts from the cranial and caudal divisions of the right lateral lobe were often apparently of equal size. When they were unequal in size the duct from the caudal division was generally the larger. The ruling was therefore made that when these two ducts joined, the cranial duct was always considered as joining the caudal duct.

RESULTS.

The number of ducti hepatici varied from one to nine. The curve (Fig. 3) shows the mode to be two, this condition being present in thirty-eight cases.

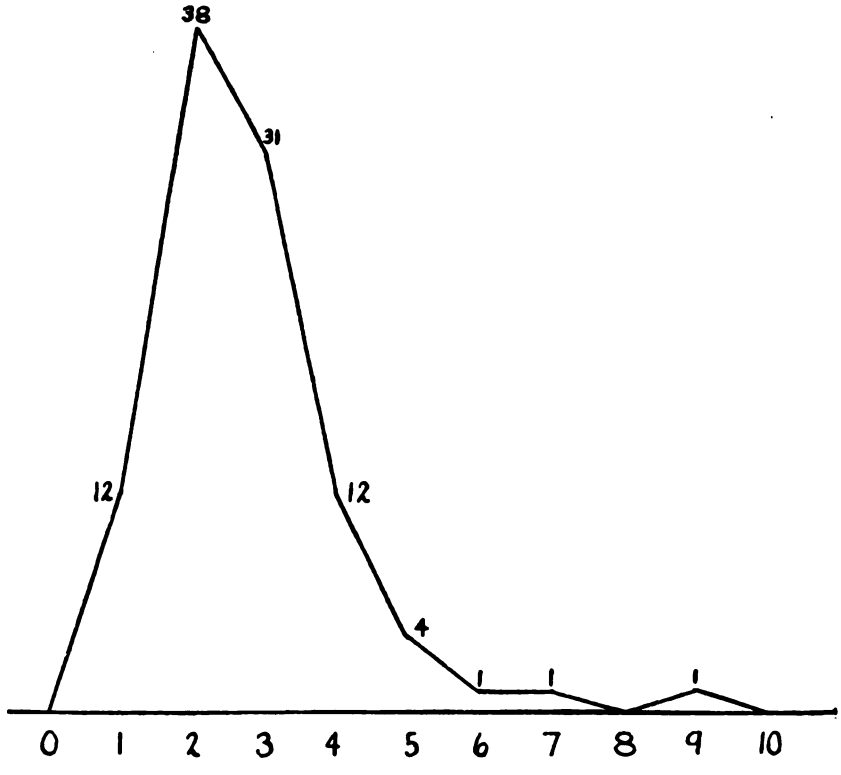

FIG. 3.—Curve of the number of ducti hepatici.

A ductus hepaticus proprius was found in twelve cases (Fig. 2). In five other cases the component ducts of the ductus hepaticus dexter joined the ductus hepaticus sinister independently (Pl. XLIX, Fig. 3). The ductus hepaticus sinister was present in ninety-nine cases; the ductus hepaticus dexter in only fifty-five cases. This great difference is due to the frequency with which the ducts from the right median lobe entered the ductus cysticus separately. The high percentage in the case of the ductus hepaticus sinister is undoubtedly due to the fact that it is formed by ducts from two large lobes, flanked on either side by a smaller lobe. The lobes which contribute to the formation of the ductus hepaticus dexter et sinister are shown in Table I.

Table I.

Lobe.	Ductus hepaticus dexter.	Ductus hepaticus sinister.
Right median	55	15
Cranial division of right lateral	55	12
Caudal division of right lateral	51	12
Quadrate	5	83
Left median	1	99
Left lateral	1	99
Caudate	14	66

The destination of the ductus hepaticus dexter et sinister is shown in Table II.

Table II.

Duct.	Ductus hepaticus dexter.	Ductus hepaticus sinister.
Ductus hepaticus proprius	12	12
Ductus cysticus	15	15
Ductus choledochus, opposite other duct	15	18
Ductus choledochus, below other duct	18	14
Ductus choledochus, other duct missing	0	37

The analysis of the ducts from each lobe is given in Table III. The destinations given are the immediate ones, the ultimate destinations have been shown in Table I.

Table III.

Ducts from / Join	Duct of right median lobe.	Duct of cranial division of right lateral lobe.	Duct of caudal division of right lateral lobe.	Duct of caudate lobe.	Duct of left lateral lobe.	Duct of left median lobe.	Duct of quadrate lobe.	Ductus hepaticus dexter	Ductus hepaticus sinister.	Ductus hepaticus proprius.	Ductus cysticus.	Ductus choledochus.
Right median lobe	....	1	0	1	0	0	5	53	12	1	34	8
Cranial division of right lateral lobe	6	...	85	0	0	0	0	6	1	0	4	0
Caudal division of right lateral lobe.	2	1	....	0	2	1	0	50	14	0	9	25
Caudate lobe	6	0	7	....	5	3	4	8	59	3	6	9
Left lateral lobe	0	0	0	2	....	2	1	0	99	0	1	6
Left median lobe	1	0	0	0	3	....	3	1	99	0	2	1
Quadrate lobe	6	0	2	0	2	22	....	2	66	1	7	8

NOTE.—In the preparation of the above tables, my laboratory assistant, Mr. R. H. Johnson, gave me efficient aid.

It will be observed that both the quadrate and caudate lobes although intimately connected with the lobes of the right half of the liver send their ducts to the ductus hepaticus sinister in the majority of cases. Reighard and Jennings have erred in stating that the ductus hepaticus dexter is "formed by smaller ducts from the right half of the cystic lobe, from both divisions of the right lateral lobe and from the caudate lobe."[1]

The typical condition of the ducts of the cat's liver must be that in which each duct is disposed according to the greatest frequency for that particular duct. Only three livers were found which met this condition (Fig. 1). Four others deviated only in not having the ductus hepaticus dexter et sinister opposite.

The vesica fellea was found to be bilobed in five instances and in one trilobed. One case was found in which two vesicae felleae, each provided with a ductus cysticus, were present (Pl. XLIX, Fig. 4). One case presented a remarkable variation in that the vesica fellea was bilobed while the ductus cysticus presented a dilatation which formed an accessory vesica fellea. (Pl. XLIX, Fig. 2.) One *ductus hepato-cysticus* was found (Pl. XLIX, Fig. 1). In no case was a *ductus hepato-entericus* found although each case was carefully examined for its presence.

The livers of several dogs and guinea pigs were also examined, but in the light of the variability here shown it is evident that a description of a few cases would possess little value. The conditions found can only warrant the statement that the individual variation often exceeded the specific differences between these three species, for some of the cats resembled the condition found in both the dog and guinea pig, while other cats were still more aberrant from the cat type.

It is evident that the diagram given by Reighard and Jennings for the ducts of the cat's liver and by Ellenberger and Baum[2] for the dog's liver cannot be accepted as typical of the respective species.

It is also evident that the ducts of the cat's liver are variable to an unusual degree, the individual variation exceeding family and ordinal differences and that the relation of the ducts does not conform to the relation of the lobes.

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[1] Reighard and Jennings. The Anatomy of the Cat. New York, 1901.

[2] Ellenberger und Baum. Anatomie des Hundes. Berlin, 1891.

PLATE XLIX.

DESCRIPTION OF PLATE XLIX.

Fig. 1. Distribution of ducts in case No. 17; one of the cases which presented a great variation in the arrangement of the ducts. It will be noted that the greatest variation is found on the right side; all the ducts coming from the various lobes enter the ductus cysticus or the ductus choledochus separately. Note especially the duct coming from the upper part of the right median lobe and emptying into the vesica fellea:—the only instance of a *ductus hepato-cysticus* found in the series. A number of small anastomosing ducts are also shown.

Fig. 2. Case 27. The peculiarities of this case have been mentioned in the text. It may be well to state that there was no obstruction present to the free flow of the bile and the walls of all parts of the ducts and dilatation were perfectly normal. That the anomaly is not an artifact was shown by the fact that the peculiarity was noted before the ducts were injected.

Fig. 3. Case 30. The ductus hepaticus dexter is absent. The ducts which usually form the ductus hepaticus dexter join independently the ductus hepaticus sinister.

Fig. 4. Case 34. This specimen shows a wide divergence from the normal. Two vesicae felleae and ducti cystici are present. The ducts from the right half of the liver join independently the right ductus cysticus, while the ducts from the left half form a ductus hepaticus sinister in the normal manner.

Fig. 5. Case 19. No ductus hepaticus dexter present. The following variations are especially noteworthy:—a duct passes from the lower part of the caudal division of the right lateral lobe forward and joins the ductus cysticus; the duct from the quadrate lobe passes behind the ductus hepaticus sinister and extending nearly the whole length of the caudate lobe joins the ductus choledochus at the *porta hepatis;* the duct from the caudate lobe passes forward, behind the ductus hepaticus sinister and joins the ductus cysticus.

Fig. 6. Case 10. No ductus hepaticus dexter present. The duct from the cranial division of the lateral lobe joins the ductus

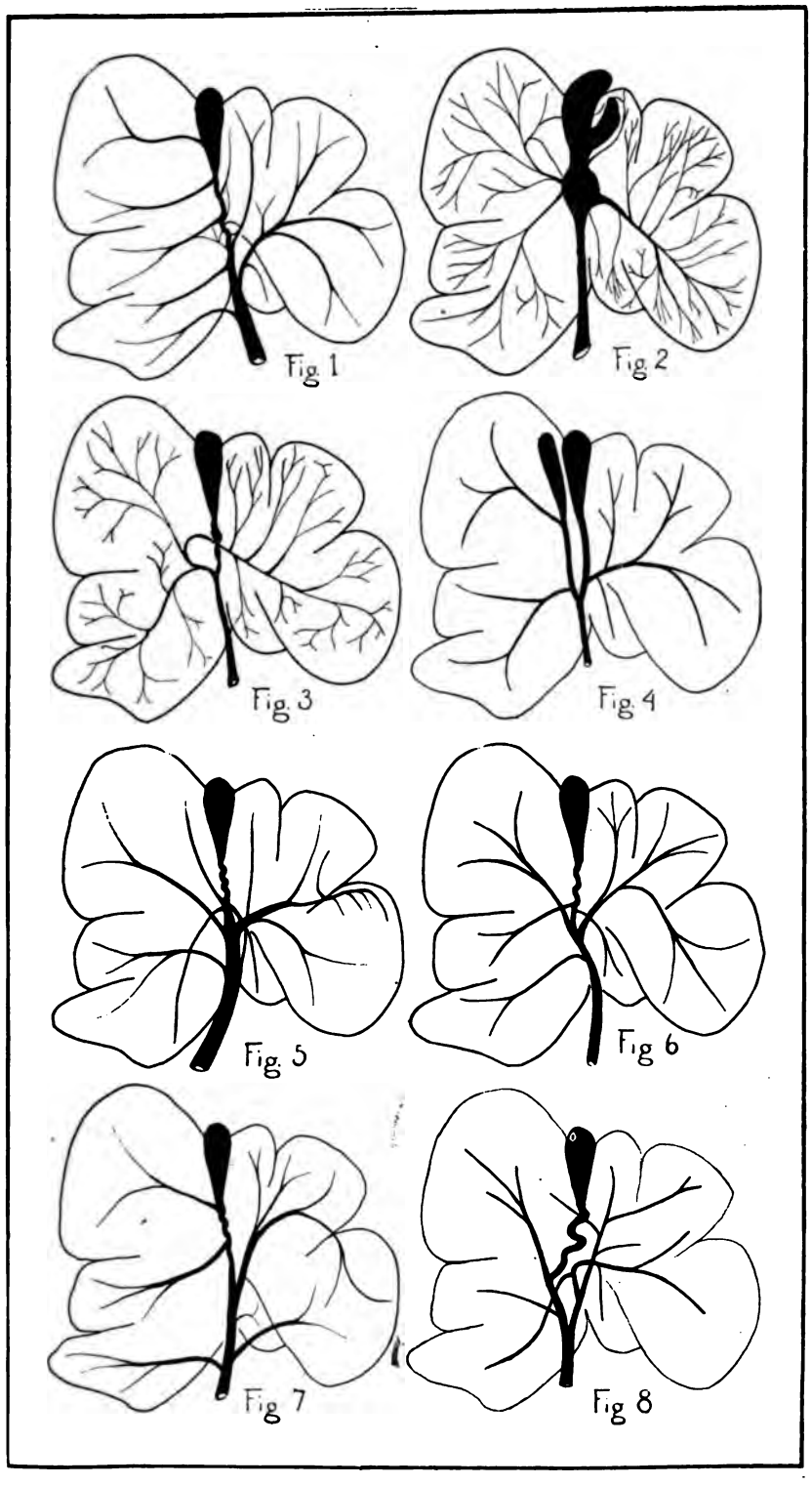


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8

cysticus. The duct from the caudate lobe joins the ductus cysticus, the same as in figure five.

Fig. 7. Case 11. No ductus hepaticus dexter present. The ducts from the lobes of the right half of the liver are independent of each other; those coming from the right median and the cranial division of the caudate lobe join the ductus cysticus, while the duct from the caudal division of the right lateral lobe joins the ductus choledochus within the folds of the *ligamentum hepatoduodenale*. On the left side the duct from the caudate lobe joins the ductus choledochus and the ducts from the caudal portion of the left lateral lobe unite to form a single duct which passes through the caudate lobe and joins the ductus choledochus within the folds of the *ligamentum hepatoduodenale*.

Fig. 8. Case 70. The ductus hepaticus dexter et sinister is present. The ductus cysticus joins the ductus hepaticus dexter some distance before it unites with the ductus hepaticus sinister. The duct coming from the caudal division of the right lateral lobe passes behind the ductus hepaticus dexter and joins the main duct coming from the left lateral lobe.

A STUDY IN THE VARIATIONS OF PROPORTIONS IN BATS, WITH BRIEF NOTES ON SOME OF THE SPECIES MENTIONED.

BY HENRY L. WARD.

Custodian of the Public Museum of the City of Milwaukee.

In recent years much attention has been given to the vertebrate fauna of North America, and the number of more or less authoritatively recognized species has multiplied with great rapidity. In mammals this increase, as well as a general overhauling of the nomenclature, has been accelerating from year to year.

In 1885 there were recognized 363 land mammals from the North American Region; in August of the present year this number had increased to about 1,700 of which 304 were the result of the last twenty months.

Much of this increase is due to the recognition of subspecies founded on more or less marked peculiarities shown by geographical races. To clearly distinguish characters due to a particular habitat from those due to individual variation is consequently a matter of prime importance. To study individual variation successfully it is important that a large series of specimens from a particular locality be examined, and it is better that one person make all of the observations, measurements, etc., and as nearly as possible at one and the same time so that the conditions governing their accuracy may be as uniform as possible.

Some years ago, when living in Mexico, my interest in bats was particularly active as I had several new species to describe. I had made considerable collections in various places, particularly in the states of Morelos and Veracruz, and the opportunity

to make a study of individual variation was furnished by an accident that confined me to my room for several weeks. The variations noticed were mostly such as could best be recorded in measurements.

The specimens measured were all preserved in alcohol, used as weak as possible, and were mostly examined within a comparatively short time after collection. The measurements, excepting length of head, were taken with a needle-point compass and applied to a diagonal scale giving tenths of a millimeter; but in the record fractions were disregarded and the nearest whole number used. The length of head was measured between the parallel jaws of a caliper registering millimeters. Every measurement was taken at least twice to guard against possible error and all were taken in as nearly as possible the same manner. The length of body and the measurements of the ear would naturally be the most liable to variation and probably would not be repeated by another person with exact correspondence; but the measurements of the metacarpals and phalanges of the wings allow of no increase or diminution due to degrees of extension and so may be considered wholly reliable, subject only to the error of personal equation. Where peculiarities, such as marked differences in proportion, were noted, the specimens were again subjected to examination for possible error. All specimens showing malformations due to injury were excluded so that the series may be relied upon as normal. A large number of the specimens were captured by hand thereby avoiding broken bones. Where specimens were shot and bones were broken measurements of these broken members were not taken and the blanks in the lists are accounted for by this or other accidents rendering such measurements unreliable. The list numbers used are those with which the specimens are recorded in the museum in Tacubaya of the Comision Geografico Exploradora de Mexico; and my thanks are due to Prof. F. Ferrari-Perez, chief of the Natural History Section of this commission for allowing me to use these specimens as well as for many other favors.

As a study in individual variation in this group of mammals, the making of the lists seemed worth my while and as some species were represented by a larger number of specimens than are usually at the disposition of naturalists for examination, the publication of the tables may be of interest.

In a recent paper on "Racial Variations in Plants and Animals with special reference to the Violets of Philadelphia and Vicinity," Witmer Stone says: "In birds and mammals the individual variation in size, after making due allowance for age and sex, is exceedingly slight, and the same may be said of color, provided the additional allowance for season is made, so that *very slight differences in measurements* or in shades of color, which might appear trivial, are really constant and perfectly reliable as indications of the differentiation of a distinct form." Pro. Acad. of Natl. Sci. of Philadelphia, Oct. 1903, p. 658. The italics are mine.

The general truth of this statement I do not wish to dispute, but it is a question whether zoologists possess sufficient data to enable them to determine the extent of these "very slight differences" in many species or groups of mammals; in other words, whether the range of individual variation in measurements has been sufficiently exactly determined for practical application. At all events any additional data, such as is herewith presented, can only serve as a farther aid towards the clearing up of this point which, to the best of my knowledge, requires still farther elucidation.

The exact amount of variation in the measurement of any member in any of the species of bats here tabulated is readily obtained at the left margin of the tables.

How near my localities represent the centers of habitat of the different species I am unable to say; though from the large numbers of some of the species resident in the localities where collections were made the presumption is that they were well within their proper territory.

In order to facilitate comparisons between the different members of any individual or the measurements of any member between the different individuals of the same species, I have graphically plotted them in the manner I think best adapted for this purpose. Reading down from any individual, as noted by number and sex at the top of the diagram, we find in succession the measurements of the different parts, each of which can be read in millimeters by referring to the left margin where is noted the scale in millimeters for each member.

At the right of the diagram showing the measurements of any member in all of the individuals of a species is a binomial curve which shows the number of individuals having a given

length for each of the several measurements noted. In some instances these curves present indentations suggestive that an insufficient number of individuals were measured. It will be noted, however, that this irregularity of curve is not always more marked where the number of individuals is the more restricted. Were the specimens from different localities some of the curves with double or multiple apices would suggest geographical races with differing maxima of measurements; but under the circumstances the dearth or occasional absence of certain intermediate measurements seems to be fortuitous.

In this study care has been taken to restrict the specimens examined to one locality, and frequently to a single cave, except in the case of *Nyctinomus braziliensis* which is generally recognized to have a rather wide distribution. There is not over 75 miles distance between the extremes of the localities represented in the tabulated specimens of this species. The differences in altitude would perhaps be the factor most apt to produce variation among these, but the diagram does not seem to indicate that such has been the case. Although for my own purposes I noted the measurements of several other species and of some additional small lots from other localities of the species herein tabulated, I have not considered it advisable to use these measurements in this connection.

In the present study the eight species are represented by 415 specimens which afford a total of 6,863 measurements.

In scanning any of these tables the general similarity of many of the graphs is readily seen. Vertices and nadirs are usually found to follow their kind in any given specimen though minor variations somewhat obscure the apparent correspondence in trend of the graphs. Those of length of head and body compared with those of length of tail appear the most dissimilar because of the more extensive range in actual length in these than in other measurements; though in examining the proportionate amount of variation it is found to be less than between some other measurements.

In most of the measurements of parts the variation in actual length is moderate, though were this computed on the mean or average length it would be found in some instances to be proportionally as much as 33 per cent. In a considerable number of instances the binomial curves following the graphs show that the maximum number of measurements recorded corresponds

very well with the mean of these measurements; that their apices are approximately perpendicular to the centers of their bases. The smaller the number of specimens used in any table the less, as a general thing, do the binomial curves approximate this correct proportion; although, in some instances, curves of multiple apices show in measurements of considerable series.

Notwithstanding the general correspondence in proportions among these specimens, exceptions are not rare; and in some instances the graphs have nearly reversed themselves. A remarkable instance is seen in *Mormoops megalophylla* between the specimens from number 814 to 822 in which the proportions of length and tail show great discrepancies. Various instances can be found in any of the tables where a member considerably above the mean of its class is coupled with another decidedly below its mean.

Mormoops megalophylla Peters.

Thirty-three specimens collected near Jalapa, Veracruz, February 23, 1891, by H. L. Ward and C. M. Teran.

Other specimens of this species were taken at Cerro de Jojutla, District of Juarez, Morelos.

This species, *Natalus stramineus, Chilonycteris rubiginosa,* and *Dermonotus davyi* were found in a remarkable lava tunnel some miles northeast of Jalapa, Veracruz, in the bottom of the cañon of Actopan, within the *tierra caliente* or hot zone. The nearest place that the lava could have come from was the volcano of Perote about 30 miles west and some 3,000 feet above, near which similar lava tunnels occur. The only apparent entrance to this one was through a hole about a yard in diameter formed by the breaking through of the roof at one point. The cave or tunnel is known to the inhabitants of this district because of the great number of bats that nightly issue from this hole in the nearly level ground, and from them has received the not inappropriate name of El Infernillo, or the little hell. As far as I could ascertain no one had entered the tunnel previous to my visit. My assistant, Teran, and myself let ourselves down by a rope, which we tied to a piece of wood placed across the opening, until we reached a conical pile of rocks formed by the breaking down of the roof some 20 or 30 feet above. At this

point is a sort of rotunda about 200 feet in diameter by perhaps 50 feet in height. Slanting down at a moderately steep grade is a tunnel extending only a few rods before it is choked with soil that apparently has been deposited by water entering the hole in the roof. In the opposite direction the tunnel, sloping upward, extends for an unknown distance and is of ample dimensions, perhaps 30 feet in width by the same in height, very regular in section and but slightly serpentine in direction. The temperature was decidedly hot and the atmosphere close and oppressive. For some distance a faint glimmer of light, reflected from the rotunda, furnished sufficient illumination until a change in the pitch of the tunnel shut off this supply and we were forced to light our candles. A few desultory squeaks, now near, now far away, increasing in number as we advanced, the flitting of shadowy wings and an occasional swish as one came near our ears, showed that the bats were alive to our presence.

Shading our candles, we could see a short distance ahead, and there, clinging feet uppermost to the sides of the cave, from roof almost to the floor, were bats as far as we could see. Those near by and on the lower levels, with their heads thrown up, were standing on their wrists with bodies clear of the walls, ready to let loose and fly away at a moment's warning. By making stealthy, rapid sorties we were able to capture a number with our hands; but were more interested in noting the methodical manner in which they disposed themselves—each species in a band of some feet or yards in width; then a slight vacant space, followed by a band of another species. Hand collecting was rather slow, and time was pressing; so we tried a few shots to good effect. The roar and concussion started the bats by the myriad, and in a moment the air was filled with thousands of flying forms. Instantly our candles were blown out by the wind from their wings, and in the Stygian darkness we were continually struck severe blows in the face and body by these living missiles, the roar of whose wings mingled with their shrieks was as deafening as the passage of an express train in a railway tunnel. For a moment it seemed impossible to stand against the storm of swirling and eddying bats that in their wild career seemed to have entirely lost their usual knack of avoiding objects. Soon the roar quieted so that I could hear Teran shouting to me not over twenty feet away. He was a high-strung, nervous lad, and that moment's experience had put

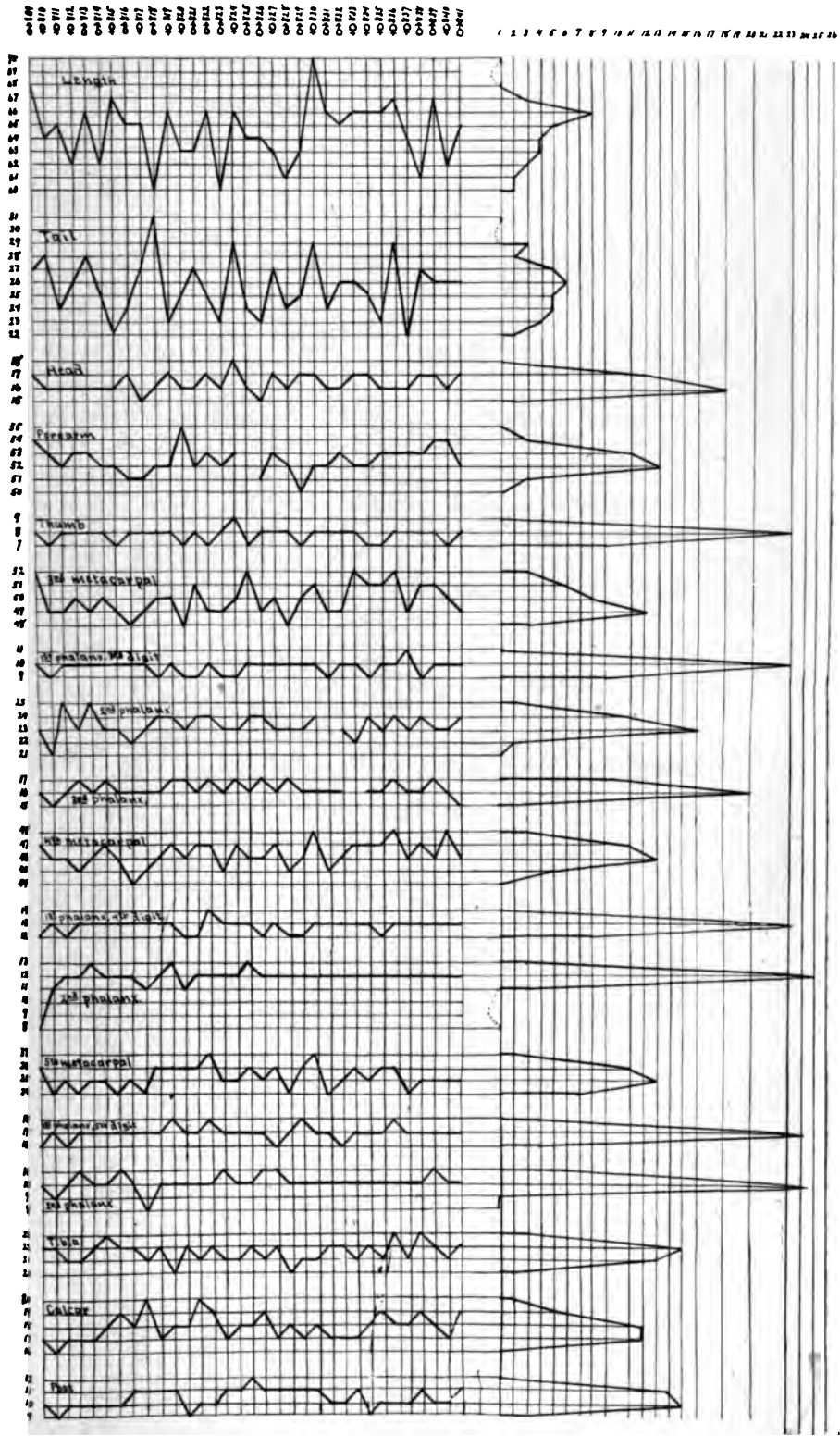
him on the verge of hysterics; but a few suggestions on my part shamed him into self-control.

Then we tried to re-light our candles, but every match seemed to attract more bats to blow it out, until we both sat down, put the candles between us, held our big sombreros at the sides and lit up.

We then discerned that the very ground on which we sat was literally a mass of moving, crawling spiders or spider-shaped insects. Taking more careful note of our surroundings, we found that the rock, so apparent at the entrance, was nowhere exposed, unless, perhaps, on the roof, which we could not see distinctly. The floor for at least two feet deep—how much deeper we had no way of telling—was composed of a dry, spongy guano, into which we sunk at least a foot at every step. The sides were the same; and some places where it had warped away from the walls, showed it to be not less than eighteen inches thick.

Anxious to see what there was beyond, we went on, and time after time experienced repetitions of the bat storm. The squeaking would swell into a shrill piping, augmented, echoed and re-echoed by the walls of the cavern; the scarcely audible swish of wings would grow into a roar; the zigzag flight of a few hundred bats, dodging one another in intricate flight, would, by increase, become blurred into a seeming stream of dark bodies and then our lights and even our hats would succumb to their hurricane, and we would patiently stand and take our punishment until the wave swept by with its mad swirl of shrieking bats, and we could light up again. In this way we went on until we reached a steep incline that would be difficult and exceedingly disagreeable to climb, on account of the peculiar nature of the floor. How far we had come I do not know, probably not over 1,000 feet after getting into the bat territory, but that they extended still farther was evinced by the guano and the multitudes of bats on the walls that apparently had not been disturbed.

My experience with bats has been that while some few species seem to prefer only a mild sort of twilight, where the human eye has no difficulty in seeing, others will penetrate to such dark recesses that the eye cannot discern the faintest indication of light; though I doubt not that the bats are still able to see. When the caves have been long enough and passable I have many times gone beyond the range of the bats, and have fancied



Measurements of 33 specimens of *Mormoops megalophylla*.

that their position seemed to bear certain relations to the configuration of the caverns, and, consequently, to the distance to which it was possible for some faint trace of light to be reflected.

I would not dare hazard a guess at the number of bats then in the cave; but it was apparent that many millions must have lived there during the time that the guano had been accumulating.

On returning our experiences were much the same as when coming in. Approaching the entrance we found that a large number of bats had been driven before us and had clustered together in a high, dark portion of the roof just before the tunnel debouched into the rotunda. Swinging my gun rapidly, so as to cover as large an area as possible, I fired both barrels, upon which a perfect shower of dead and wounded bats fell to the ground. The result of this double shot was 171 bats picked up, while probably many wounded ones escaped us, and a number too badly shot were not taken. We were soon out of the cave, and when I procured a collecting bottle to put insects in my surprise was great to find that there was not one of the myriads covering the floor of the cave to be found anywhere about our persons or paraphernalia.

I have seldom found more than two species of bats inhabiting the same cave, and they generally belonged to different families. In this case the attractiveness of the situation and the abundance of insect life in the tropical vegetation surrounding the cave seem to have lessened the strife for existence to such a low ebb that thousands of each of these four species could live in harmony together in "the little hell."

The opposite graph exhibits the correspondences and discrepancies in proportions as found in the thirty-three specimens measured. The more striking ones between length and tail as shown by the specimens from 814 to 822 have been alluded to. Although these two curves have, in reality, a good many points of similarity, their differences are so striking as to convey at the first glance the impression that they have little in common.

In some instances, such as from number 832 to 839, in comparing the first and second phalanges of the third digit, the lack of agreement would suggest the possibility of the first measurements having by accident been advanced one place or of the second having been carried back an equal distance. There ap-

pears to be no possibility of such mistakes having been made as all the measurements of each individual were made and recorded one after the other before the next specimen was taken in hand. These were written in figures from left to right across the ruled pages and are now in my possession. Where such anomalies appear in the graphs I have reproved them from the original sheets to assure myself that errors have not been made in the plotting.

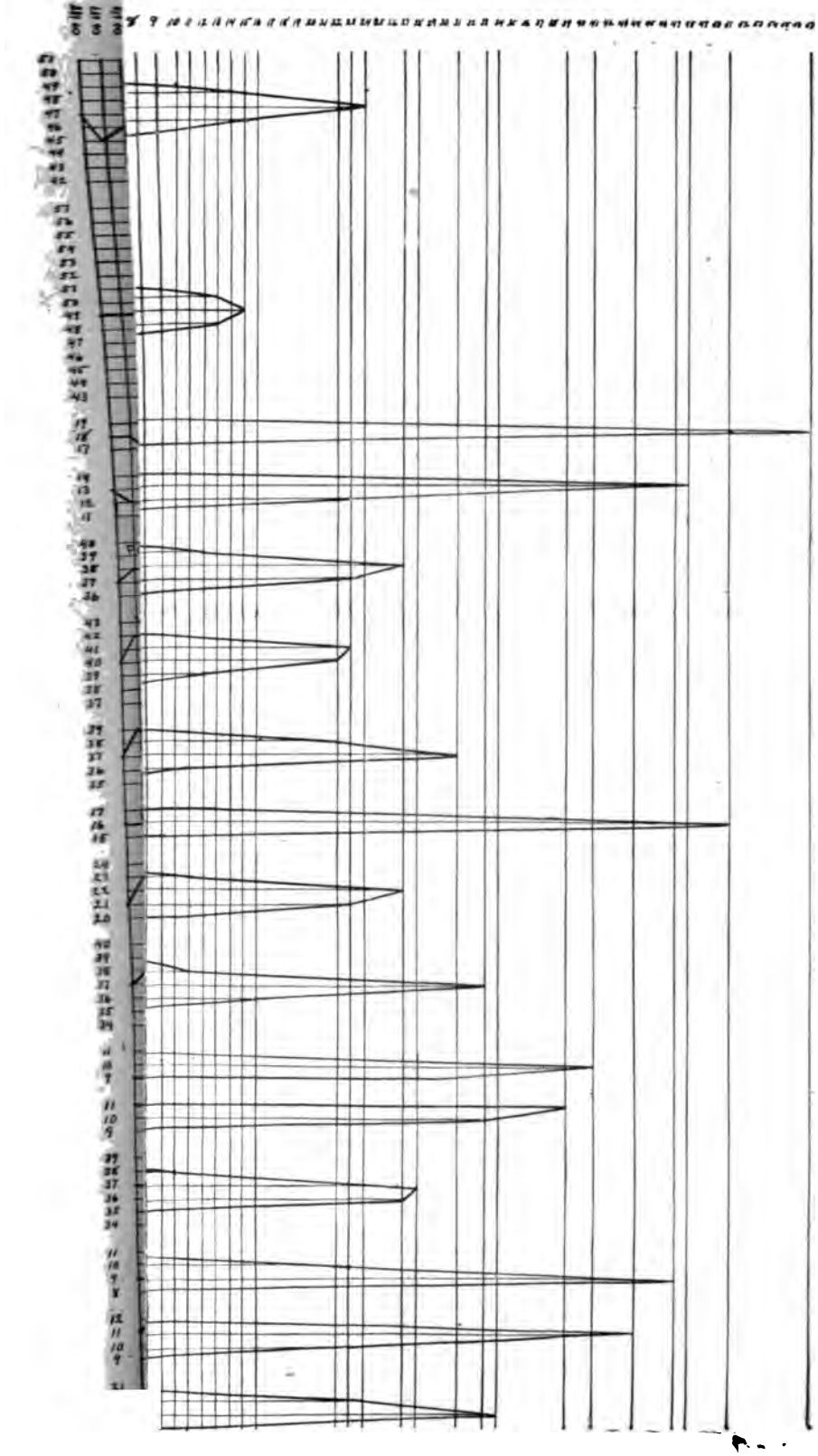
The third metacarpal may be as long as the forearm or it may be 7 mm. shorter. The second phalanx of the fourth digit may equal the first or be only two-thirds as long. The thumb may equal the first phalanx of the third digit or be only seventy per cent. of its length. In the usual points of comparison there is so much difference in the lengths of the various members that their measurements do not overlap but merely approach or recede in varying degrees.

It may be considered that No. 809 has an abnormally short second phalanx to its fourth digit as the next shortest one is 3 mm. longer. However, as this joint showed no signs of injury and the other phalanges indicate no tendency towards abnormality, we are not warranted in excluding it or considering it other than a normal variation whose isolation a larger series probably would bridge.

Natalus stramineus Gray.

Seventy-three specimens collected near Jalapa, Veracruz, February 23, 1891, by H. L. Ward and C. M. Teran.

With the exception of the graphs of length and tail, which are rather remarkably dissimilar, there is a considerable correspondence between those of this species. Those of the head and ear show rather less of similarity than any of the others, yet as the range of variation in these measurements is so slight, three and four millimeters respectively, the real amount of proportional variation between these two members is considerably less than in others in which the trends of the graphs more closely coincide. The first and second phalanges of the fourth digit as plotted are rather exceptionally parallel; yet the extremes of proportional differences is five per cent. greater than between



the ear and head. However, the lesser lengths dealt with in the case of the phalanges, rather than a greater diversity of measurements, accounts for this disparity in per cent. of variation. The variation in relative as well as absolute length of the tail are considerable. This organ may be but 96% the length of the head and body or it may be 124 per cent. of its length. There is an absolute difference of 12 mm. on bodies differing in length by only 1 mm., viz., Nos. 699 and 742, both males. Dobson says: "Tail much longer than the head and body."

Comparing the forearm and second metacarpal we find in No. 699 that a forearm of 36 mm. may bear a metacarpal of 41 mm., while in No. 695 a forearm of 40 mm. may have a metacarpal only 39 mm. in length, a reversal of proportions.

The third, fourth and fifth metacarpals are about equal and in many cases measure the same, but either the third or fourth may be the longest or the shortest, while the fifth may be the shortest but never appears in these measurements as the longest. The proportions between the first and second phalanges of the third digit vary from 17:20 to 15:23, those of the fourth digit from equal to 9:11 and of the fifth digit from equal to 9:12.

The measurement of the second metacarpal of No. 747 is omitted because of its abnormality; measuring but 32 mm. in length and having joined to it, by a synovial joint, a phalanx 10 mm. in length. Although the average length more nearly corresponds with Dobson's "Var. a." than with true *stramineus* yet in other points it agrees best with the latter.

In the museum in Tacubaya were one or more specimens of this species collected in "southern Puebla."

Chilonycteris rubiginosa Wagner.

Forty-one specimens collected near Jalapa, Veracruz, February 23, 1891, by H. L. Ward and C. M. Teran.

There is a considerably greater agreement in the graphs of length and of tail of this species than in either of the two species already examined; and the proportionate amount of variation is less than in them. The fifth metacarpal is usually the shortest but may equal the fourth. The third is usually the longest but may be equaled by the fourth.

It will be noticed that four of the binomial curves are abnormal; and that the one of length of head and body is particularly ill-formed. In neither of them does either of the several vertices coincide with the mean of the measurements. It is quite evident that a larger number of specimens should have been compared in order to furnish normal curves for the various members and determine their average lengths. A larger series of specimens would probably have increased not only the range of variation in measurements of the several members but would also presumably have shown greater individual variation than the small series shows.

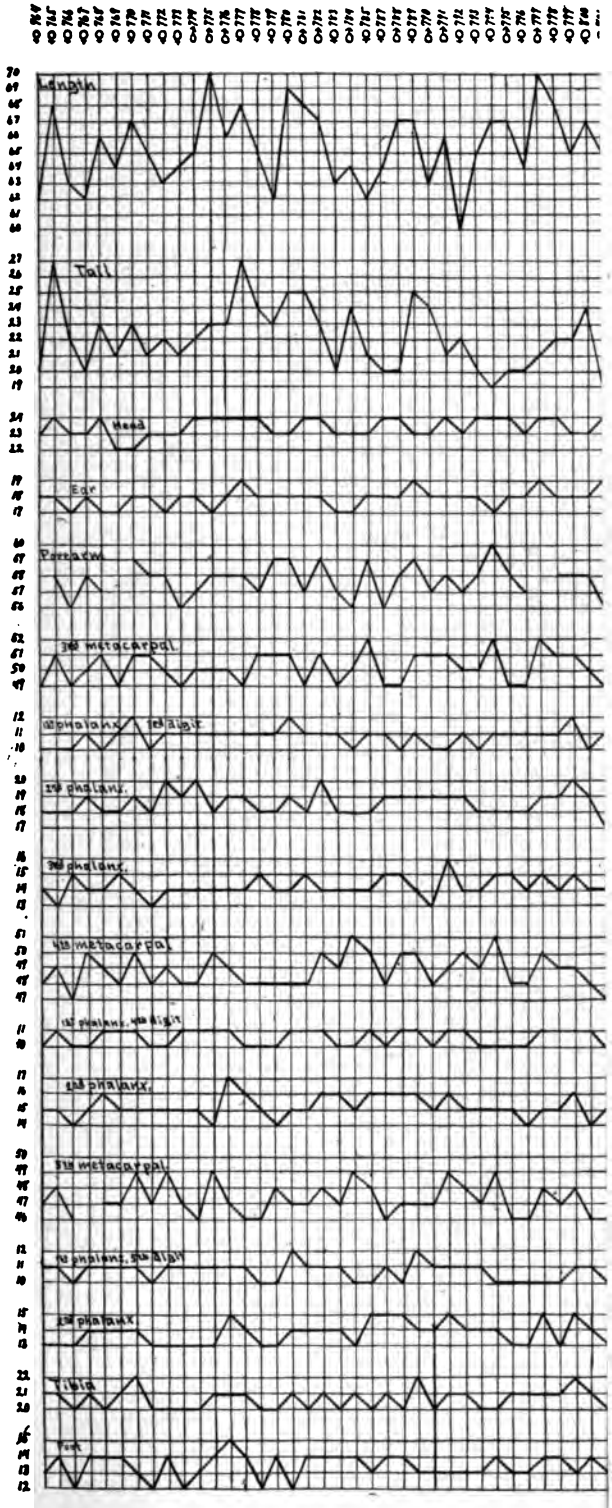
A young male, No. 786, is noticeable on account of the retarded growth of its phalanges. Its measurements are: length 49; tail 16; head 17; ear 13; forearm 41; third metacarpal 40; first phalanx of third digit 7; second 12; third 10; fourth metacarpal 34; first phalanx of fourth digit 8; second 9; fifth metacarpal 33; first phalanx of fifth digit 9; second 7; tibia 17; foot 11.

Nyctinomus braziliensis I. Goff.

Fifty-nine specimens taken from the following localities: Nos. 394 to 433 and 435 to 441 inclusive, collected in various parts of the state of Morelos between Sept. 29 and Oct. 31, 1890, by H. L. Ward and C. M. Teran. No. 434 at Ixtapalapa, Federal District, June 29, 1890, by H. L. Ward. Nos. 442 to 452 inclusive, were collected March 8, 1888, at Tacubaya, Federal District, by A. Samaneigo.

The specimens listed, although from several localities, were all taken within a radius of 75 miles and are probably quite free from geographical variation, in fact the greatest variations are sometimes found to occur between specimens from the same locality.

The proportions of body and tail lengths show a moderate amount of variation. The longest and shortest measurements of the tails of the 59 specimens are found coupled with a body length of medium size; 57 mm. bodies bearing tails 31 and 38 mm. long. The extent of tail extending beyond the interfemoral membrane, as would naturally be supposed, is subject to much variation; a tail 32 mm. long having 21 mm. free while



Measurements of 41 specimens of

a tail of 35 mm. may have only 14 mm. free. The ear shows an extraordinary amount of variation in a few individuals; ranging from 12 to 20 mm. in height on heads respectively 20 and 22 mm. in length. The 12 mm. length is isolated but as the ear shows no signs of malformation it is therefore presumable that a larger series of specimens would show the connection and also straighten up the base of the binomial curve. Between the graphs of the head and the ear there is more disagreement than agreement in the trend of the lines. Isolated measurements are seen by the binomial curves to also occur in the third metacarpal, its first phalanx and in the fourth metacarpal, and only misses by one of occurring in the fifth.

A 39 mm. forearm carries an 8 mm. thumb while a forearm 42 mm. has a thumb only 6 mm. in length. Comparing the forearms to the second metacarpal we find that the forearm usually is the longer with an extreme of 45:39; in several cases they are equal and in two cases the forearm is the shorter, i. e., 40:41 and 41:42. The second metacarpal is usually shorter than the third but may be equal. The first phalanx of the third digit frequently exceeds the second but in various cases is equal and in three instances, showing no appearance of injury, the second phalanx is the longer. Comparing the second to the fourth metacarpals we find that they are equal in many cases, that the fourth averages larger but that in a few instances this is reversed. The fourth metacarpal runs very evenly at from 1 to 3 mm. shorter than the third. The disproportion between the first and second phalanges of the fourth digit is shown by 12:8 and 15:8.

In his diagnosis of the species in "The Bats of North America," 1893, Dr. Harrison Allen says: "The first phalanx in the third, fourth and fifth digits, exceeds in length the second." We have noted that in the third digit it may be equal to the second and in three specimens it is shorter, in one considerably shorter.

Of the 33 males examined 13 possessed gular sacs but none of the 26 females showed this peculiarity which Dobson in his monographic catalogue of the Chiroptera in the British Museum says is absent in both sexes of the species.

No. 434, taken at Ixtapalapa in the Valley of Mexico, June 29th, contained a foetus nearly ready for parturition indicating that July is the probable date of birth of this species in that region.

The specimens taken in March at Tacubaya, about three miles

from the City of Mexico, were hibernating; but I failed to note the beginning or ending of this period.

When not in a lethargic state this bat is quite savage when handled, making strenuous efforts to bite and emitting querulous, high-pitched squeaks. Failing to reach my restraining fingers it was frequently seen to bite its own wing during what appeared to be paroxysms of anger.

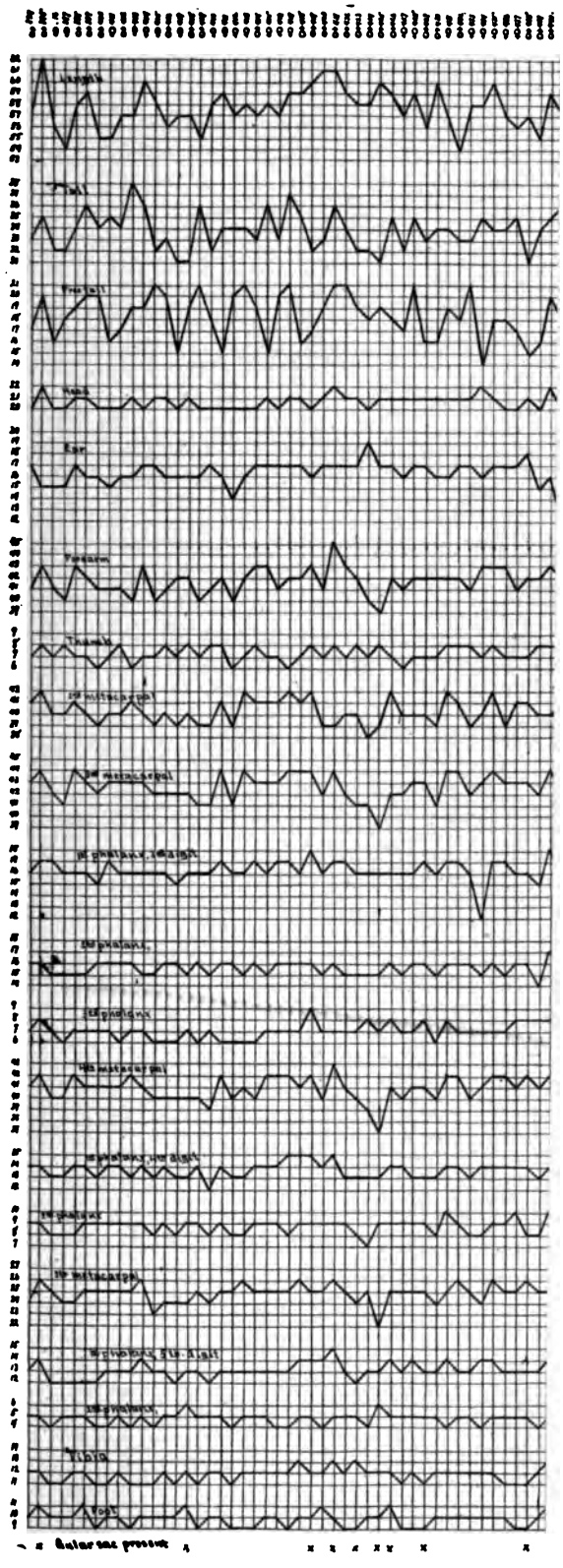
With this species I various times repeated the experiment of Spallanzani, made 200 years previous, in which he found that blinded bats avoided delicate objects, as silken threads, stretched across their line of flight with a facility equal to that of those that could see. My results were not equal to Spallanzani's for although my bats certainly showed remarkable powers of detecting an approach to an object, yet they occasionally would strike against a No. 18 wire. However, I fancy that had I, like Spallanzani, used silk threads I might not have noted this; but the wire gave an audible record of each touch no matter how light it was. It is quite possible, also, that this species is less adept on the wing than some others. Something about its makeup seemed to suggest a sort of chiropterine bulldog.

It is a familiar species, commonly found about buildings and in this respect appears to occupy among bats somewhat the position in relation to man that the house sparrow does among birds. It will tolerate considerable light. At the museum in Tacubaya it regularly lived in large numbers between rafters, set an inch or two apart, supporting the cement roof of a long portico open to the light for the entire length of one side. It has a strong, disagreeable odor and is apparently more infested with vermine than any of the other species noted.

Molossus rufus E. Goeff.

Eight specimens collected at Tetecala, Morelos, October 5th and 6th, 1890, by H. L. Ward and C. M. Teran.

The length measurements show a considerable range which, because of the very small number of specimens under consideration, run very unevenly. Agreements and discrepancies in the trend of the graphs are more or less evenly divided and the extent to which individual variation exists in the species could only by extraordinary chance be indicated by so small a number



Measurements of 59 spe

of specimens. While the amount of variation is in all probability most imperfectly shown the series is sufficient to indicate that numerous disproportions exist; probably to approximately the same extent as in the other species.

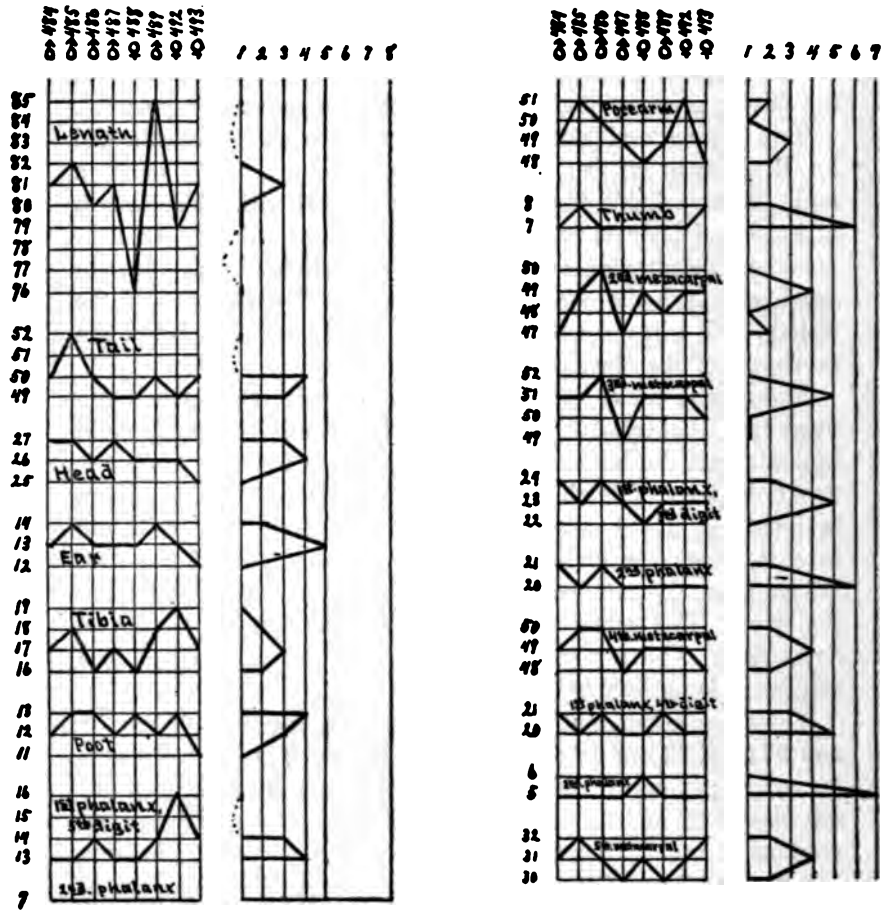
The forearm is greater or less than either the second or fourth metacarpals and is equal to or less than the third metacarpal, the second is less than the third and greater or less than the fourth, the third is greater than the fourth in the few specimens recorded.

Two young and one adult in the museum were collected by R. Montes de Oca in Soconusco, Chiapas. The adult, a male, is remarkable for its exceedingly short tail. The length of head and body is 83 mm. and that of the tail only 42 mm. Its other measurements are in all cases paralleled by the Morelos specimens with the one exception that the first phalanx of the fourth digit measures but 19 mm. which is one mm. below the minimum of the Morelos specimens.

Two young males collected in Tetecala with the other specimens from that locality were apparently recently born and would indicate that the latter part of September or first of October is about the time of birth of this species in Morelos. They were both entirely naked except for a slight fuzz about the muzzle and bristles, nearly as large as in adults, on the sides of the feet. When taken, the ears were closely adpressed so as to tightly cover thy eyes. The sexual organs and the gular pouches were well developed. The retarded development of the metacarpals and phalanges is noticeable in them.

Their measurements are as follows: lengths respectively 58 and 57; tail 32 and 30; head 22 and 21; ear 9 and 10; forearm 30 and 28; thumb 7 and 7; second metacarpal 20 and 20; third metacarpal 23 and 20; first phalanx, third digit 8 and 8; second phalanx 6 and 5; fourth metacarpal 22 and 19; first phalanx, fourth digit 7 and 7; second phalanx 3 and 2; fifth metacarpal 17 and 14; first phalanx, fifth digit 7 and 6; second phalanx 4 and 5; tibia 13 and 12; foot 11 and 12.

These specimens were taken at the hacienda of Cocoyotla, District of Tetecala, from between the closely placed rafters of one of the buildings.



Measurements of 8 specimens of *Molossus rufus*.

Desmodus rotundus E. Geoff.

Nine specimens taken from a small cavern near Zacoalpan Amilpas, District of Jonacatapec, Morelos, October 26, 1890, by H. L. WARD and C. M TERAN.

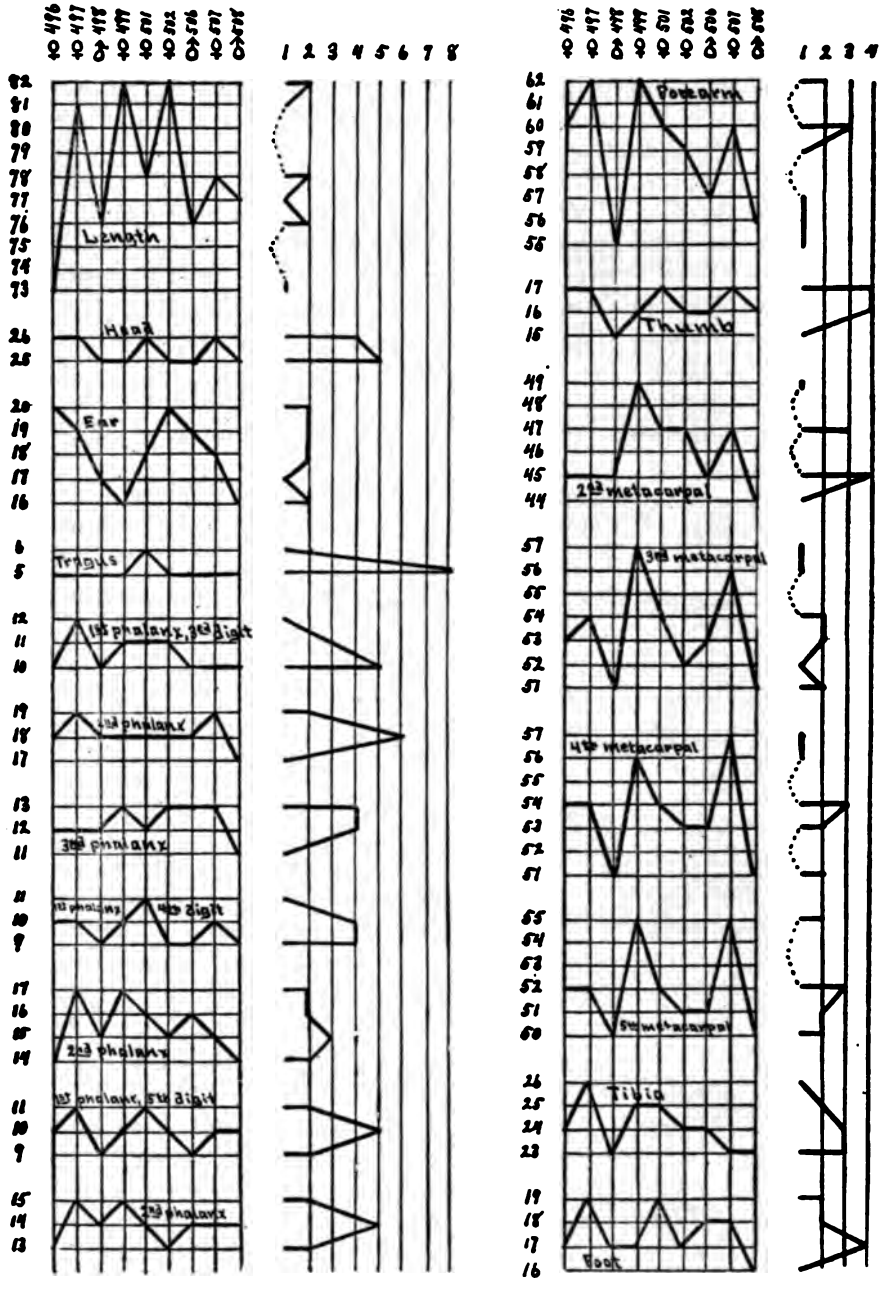
This series is altogether too small to show anything definite except that there is a considerable degree of variation in absolute lengths of several of the members and a moderate amount of individual variation. Between the length and ear we find a complete reversal of proportions, i. e., the shortest individual has one of the longest ears and one of the longest individuals has one of the shortest ears. Lesser discrepancies occur in comparisons of other members. The females appear to rather exceed the males in size though this may be only due to an insufficient series.

Dobson, Catl. Chiroptera, Brit. Mus., p. 547, says: "Thumb very long and strong, much longer than the foot, . . ." My series of specimens indicates that the foot is equal to or longer than the thumb. In Dobson's diagnosis we also read "metacarpal bones of the fourth and fifth fingers progressively slightly shorter than that of the middle finger." In No. 502 we find that the fourth metacarpal slightly exceeds the third.

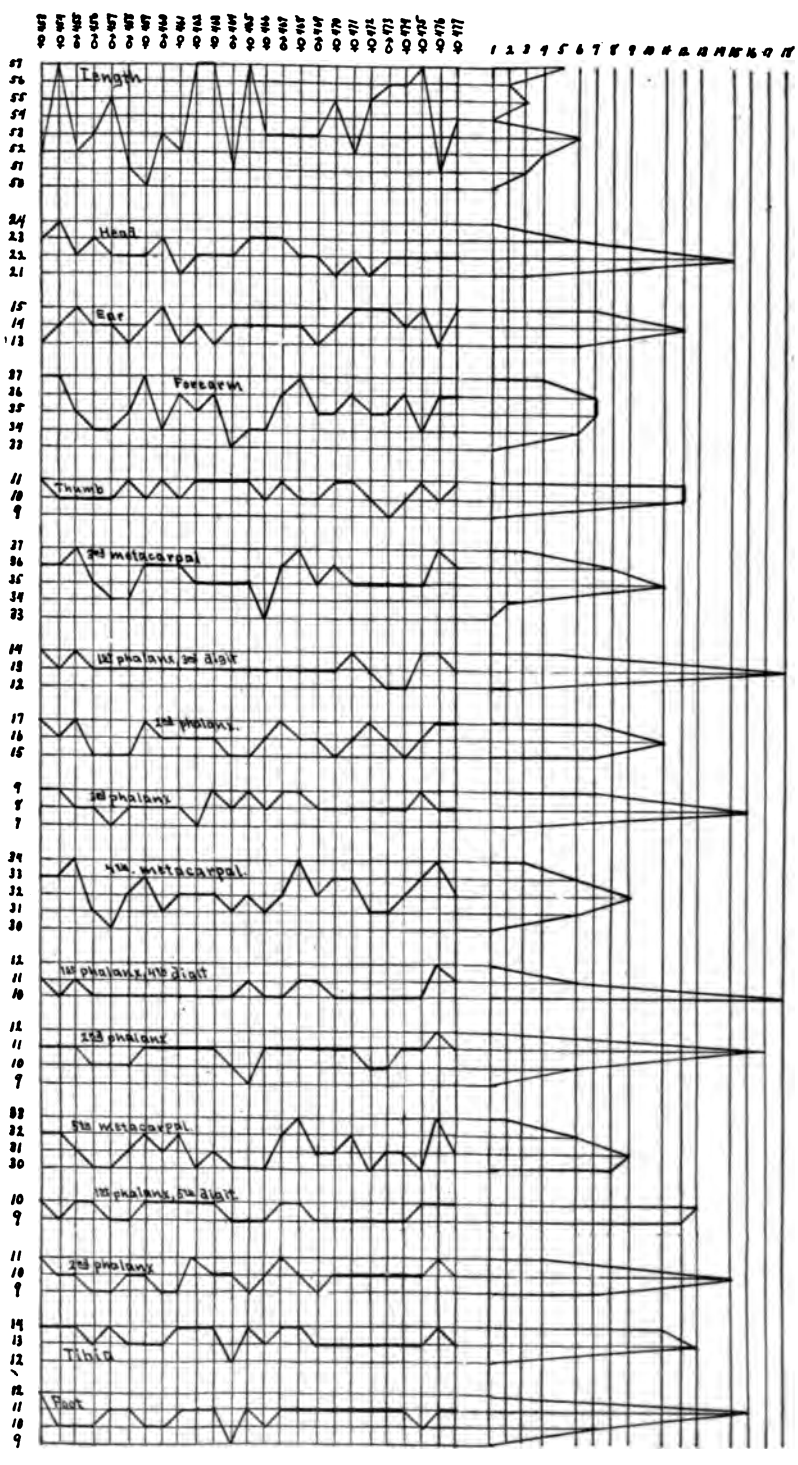
This vampire was probably responsible for the depredations on our saddle and pack animals that were of almost nightly occurrence in central and southern Morelos; for, I believe, no other vampire is known to inhabit that region.

A peculiarity that I have not noted in any other species of bat is that its excrement is a thickish black fluid, very likely due to its probably exclusively blood diet. On emerging from the shallow cave in which they were taken I found my tan colored boots smeared as if with liquid blacking.

The time of parturition is probably early in November, for No. 499 contained a nearly ripe foetus. The weight of the preserved (alcoholic) female was 27.2 grms. and of the foetus 7.1 grms. The species was found in only semi-darkness; but disliked to escape into the strong sunlight outside the cavern and so kept circling back and fourth. They bit viciously when handled. Four immature specimens were taken at the same time. They are not greatly smaller than the adults in most of their measurements; the difference being chiefly noticeable in their distal phalanges.



Measurements of 9 specimens of *Desmodus rotundus*.



Measurements of 25 specimens of *Glossophaga soricina*.

Glossophaga soricina (Pallas).

Twenty-five specimens collected in the District of Cuernavaca, Morelos, Oct. 1st, 1890, by H. L. WARD and C. M. TERAN.

The variations in proportions in this species are nearly all quite moderate, probably not more than would naturally be expected in a mammal of its size. Slight discrepancies in the graphs showing measurements will be noticed in many instances.

Length of head and body to that of head alone varies from 57:22 to 50:22; of length to forearm from 50:37 to 57:34; of head to ear from 22:15 to 22:13; of forearm to thumb from 33:11 to 35:9.

The forearm in eight specimens is longer than the third metacarpal, in nine specimens it is equal and in eight specimens it is shorter.

The fourth metacarpal may be 3 mm. longer than the fifth, or of the same length.

In the fourth and fifth digits the first phalanx may exceed, equal or be less than the second.

These bats were found clinging to the roofs and sides of the artificial galleries penetrating the large mound upon the summit of which is situated the massive stone ruins of Xoxicolco.

Myotis velifer (J. A. Allen).

One hundred and sixty-seven specimens collected at Las Vegas, Veracruz, Feb. 19–21, 1891, by H. L. WARD and C. M. TERAN.

Comparing the length of head and body with that of the tail, we find a 57 mm. body with a 35 mm. tail and a 52 mm. body bearing a 47 mm. tail, both males. Between the head and ear we find the extreme between 19:14 and 18:16. Comparing the length of head and body with the forearm we find a 51 mm. body with a 46 mm. forearm and a 60 mm. body with a 42 mm. forearm. The forearm usually exceeds the 3rd metacarpal but in one instance is found to be equal. Between the third metacarpal and its first phalanx the greatest variation is between 39:14 and 40:12. Comparing the first and second phalanges of the third digit we find the variation expressed by

15:11 and 13:12. The third metacarpal may be longer, equal to or shorter than either the fourth or fifth. Between the fourth metacarpal and its first phalanx the extremes are between 42:11 and 38:12. Between the first and second phalanges of this fourth digit the variation is 11:10 and 11:7. The fourth metacarpal is usually slightly longer than the fifth but may be the same length. The variation between the fifth metacarpal and its first phalanx is expressed by 36:11 and 39:9. Between the first and second phalanges of the fifth digit the extremes are 10:7 and 10:5.

This species I also collected at Cuernavaca, Morelos and at Ixtapalapa, Federal District, where it occurred in small numbers. At Las Vegas, a little hamlet on the northern slope of the Volcano of Perote, not far from Jalapa, Veracruz, I found this bat in great numbers and my collecting was limited only by my desires.

Here was a lava field honeycombed by tunnels formed by the running out of the molten interior after the surface had become too cool to flow. The tunnels were approximately parallel and were frequently superimposed. Three were the largest number that were noted in the same vertical plane. In many cases the vertical diameters were thirty-five feet or more. The floors were comparatively smooth and flat, with the walls springing at about right angles from them. Some of these tunnels were fifty feet or more in width and in section nearly as regular and with as finely arched roofs as if artificially constructed. Entrance was had through holes in the roofs that were probably caused by earthquakes breaking the thin shells. Frequently superimposed tunnels were united in the same manner, and rapid walking with the faint and uncertain light of unprotected candles was somewhat dangerous, as it was not easy to see that the bottom of a tunnel had fallen out until one was close to the brim. The temperature of these tunnels was quite low and the bats were mostly found clinging to the ceilings in a state of lethargy. They were not much disturbed by our lights nor was it necessary to be cautious in approaching them. The gun was used only to determine the identity of those out of reach. When held in the hand for a few moments they woke up, gave utterance to high pitched squeaks and struggled to escape. They were mild mannered and not inclined to bite.

Although during the three days that I hunted this region I

Tra

visited many tunnels and saw many colonies of bats, some of them probably containing several thousand individuals, all belonged to this one species with the exception of a few individuals of a then undescribed form, *Pipistrellus veraecrusis* (Ward), found living in close proximity to *M. velifer,* and a few individuals of *Corynorhinus macrotis* (Le Conte) living separate from each other as well as from the other species.

In the foregoing diagrams and notes are presented the complete data of the observed variability of these eight species of bats. From it the reader may judge for himself how much variation appears to be normal and how much may be considered exceptional.

In order to present the amount of proportional variation in these various species of bats, to facilitate a comparison of one species with another and to exhibit the degrees of average of maximum variability of the several comparisons, the following table has been constructed.

It will be noticed that the relative amount of maximum variation of any comparison varies more or less in the different species so that a comparison that may be subject to little variation in one species may be less stable in another.

The percentage of the first term of the comparison is calculated upon the second; thus with a head of 22 mm. and a length of 50 mm., the former is computed as 44, while a 22 mm. length of head with a 57 mm. length of head and body is computed as 38.5 and the range of variation is the difference, or 5.5 per cent. When a member is compared with a shorter one a variation in absolute length will make a much greater variation in percentage than were the comparison made with a member of equal or greater length. I have followed the order of comparing a member with its proximal supporting member, or in case of metacarpals, considering the second as proximal to the third, etc..

Maximum variation in proportions of each species expressed in percentages.	*Molossus rufus.*	*Desmodus rotundus.*	*Glossophaga soricina.*	*Mormoops megalophylla.*	*Chilonycteris rubiginosa.*	*Nyctinomus brasiliensis.*	*Natalus stramineus.*	*Myotis velifer.*	Average of the eight species.	Serial order of average variation.
Head, compared to length of head and body	3	5	6	4	5	6	9	7	5.62	3
Tail, compared to length of head and body	4	.....	.....	19	11	13	28	29	17.33	21
Forearm, compared to length of head and body	7	11	15	13	13	16	17	20	14.00	17
Auricle, compared to length of head and body	6	16	13	.....	12	35	17	15	16.28	20
Thumb, compared to length of forearm	3	3	7	4	.....	6	.....	.....	4.60	2
Second metacarpal, compared to length of forearm	6	9	.....	.....	.....	16	16	.....	11.75	15
Third metacarpal compared to length of forearm	6	6	9	13	7	10	11	11	9.50	10
Fourth metacarpal, compared to length of forearm	6	5	9	9	10	12	11	14	9.87	11
Fifth metacarpal, compared to length of forearm	6	3	5	8	8	9	11	14	8.62	8
Third metacarpal, compared to second metacarpal	6	9	.....	.....	.....	8	10	.....	8.25	7[1]
Fourth metacarpel, compared to second metacarpal	6	7	.....	.....	.....	15	13	....	10.25	12
Fifth metacarpal, compared to second metacarpal	4	9	.....	.... ..	.....	10	10	.....	8.25	7[2]
Fourth metacarpal, compared to third metacarpal	2	4	9	8	3	5	6	8	6.25	5[1]
Fifth metacarpal, compared to third metacarpal	5	2	7	7	8	6	8	13	7.00	6
Fifth metacarpal, compared to fourth metacarpal	5	2	9	7	6	7	6	8	6.25	5[2]
Third digit.										
Third digit compared to third metacarpal	.. ..	7	12	12	12	23	.....	.....	13.20	16
First and second phalanges, compared to third metacarpal	6	7	10	10	8	19	14	9	10.37	13
First phalanx, compared to third metacarpal	4	4	6	5	4	15	5	5	6.00	4
Second phalanx, compared to first phalanx	4	32	19	58	35	32	36	21	30.12	24
Third phalanx, compared to second phalanx	.....	9	16	11	16	20	.....	.....	14.40	18
Fourth digit.										
First and second phalanges, compared to fourth metacarpal	3	6	8	14	3	11	9	11	8.75	9
First phalanx, compared to fourth metacarpal	3	3	5	4	3	5	6	5	4.25	1
Second phalanx, compared to first phalanx	6	30	28	33	33	18	22	27	24.62	23
Fifth digit.										
First and second phalanges, compared to fifth metacarpal	12	6	12	10	10	22	11	10	11.62	14
Second phalanx, compared to first phalanx	10	28	21	22	33	18	33	25	23.75	22
Foot, compared to tibia	17	9	14	14	14	22	.....	.....	15.00	19

In the above table, in the column of averages, we find that the least variation is shown by the proportion of the first phalanx of the fourth digit compared to its metacarpal and next by the thumb to the forearm. In both these cases a short member is compared to a long one and the percentage would naturally be low. It is also noticeable that there is comparatively little disproportion shown in the comparisons of the metacarpals with one another because although while the lengths are considerable they are approximately equal. Wherever a long member is compared to a short one the percentage of variation becomes at once more elevated, a fact that must be borne in mind in order not to misinterpret this table. Although this method of showing the comparative variations of parts is faulty and liable to be misleading, yet after all it seems to me to be the fairest way to treat the matter. A comparison of these by differences in actual measurement expressed in millimeters would probably be more misleading as a few millimeters more or less on a long bone counts for little, whereas it may greatly alter the proportions of a short one. It should also be borne in mind that this table does not show the proportionate variation for the species but only for individuals. There are several other forms of comparison that it would be interesting to make; but my original object in making these measurements was to determine, for my own use, the value of such common descriptive terms as "—— three-fifths the length of ——," "—— slightly longer than ——," etc. Most of them are found to be unwarranted by the facts in the case.

As the second metacarpal normally bears no phalanges it would be expected that its proportionate length would be less constant than the others and this we find to be the case.

That the length of the tail compared to that of the head and body does not show as great variation as do the proportions of the first two phalanges of the digits is rather surprising. These latter show the greatest variations of any of the parts compared and the maximum of variation in five of the eight species compared, as well as in the average for all, is found in the proportion of the second phalanx to the first in the third digit, a measurement not unfrequently given by authors as among those diagnostic of species.

From the various tables of species and the remarks under them, it will be seen that it is quite unwarranted to make comparisons of the relative measurements of bones of bats for specific

distinctions when the parts compared are of only a few millimeters difference in length; for the probabilities seem to be that an examination of a sufficiently large number of specimens will show some individuals that reverse the proportions.

Of the measurements taken a number are omitted from some of the species. Selecting the sixteen comparisons summarized in the above table that are common to all of the species, and obtaining the average of the extremes of all of these for each species, they arrange themselves as follows (to which, for convenience, I have added the number of specimens of each species used in the computation):

	No. Specimens.	Av. per cent. of variation.
Molossus rufus	8	5.5
Desmodus rotundus	9	10.1
Glossophaga soricina	25	11.1
Chilonycteris rubiginosa	41	12.4
Myotis velifer	167	13.1
Nyctinomus braziliensis	59	13.4
Natalus stramineus	73	13.4
Mormoops megalophylla	33	14.

The above table shows that with the exception of *Myotis velifer* and *Mormoops megalophylla,* the species have been arranged in the order of the number of specimens examined at the same time that they were arranged in the order of their average of extremes of variation in proportions.

If the amount of variation per species was equal we would expect that the larger the number of specimens examined of any one species, the greater would be found to be the extremes of variation of proportions.

The fact that this table so nearly parallels in these two comparisons suggests the possibility that the variation in the eight species under consideration is approximately equal, and that were a sufficiently large and equal number of specimens of each of them examined the results would have been less diverse.

It is doubtful if measurements of any other group of mammals would show much less individual variation in proportions. It is my belief that no working zoologist really takes seriously the fine differences in measurements so frequently given as diagnostic of species that are known by only a few specimens; but

many such descriptions read as though the authors actually considered them of prime importance. All hunters are aware that they frequently can recognize individual wild animals from others of their kind. I am inclined to believe, from observation, that these distinctive characters are frequently those of proportion; that the long legged animal that we learn to know appears long of limb not because he is less fat than others but because his legs are actually disproportionally long so that their peculiarity strikes the eye, and that individualities of form are probably more common than are generally recognized.

Mensuration is assuredly of great value in mammalogy, but it is well to keep in mind that there is a considerable and unknown amount of individual variation affecting each species.

As a matter of record of localities I would mention the following other species of bats, mostly collected by myself or my assistant in Mexico and contained in the museum of the Comision Geografico-Exploradora at Tacubaya where they were determined by myself:

Lasiurus cinereus (Beauvois),
Jalapa, Veracruz.

Corynorhinus macrotis (Le Conte),
Las Vigas, Veracruz; Ixtapalapa and El Convento in "Diserto," Federal District.

Saccopteryx plicata (Peters),
Six specimens from a hole in a Penon on the Cerro de Jojutla, District of Juarez, Morelos, and one from under the roof of a church at Cuernavaca, Morelos.

Nyctinomops depressus (Ward),
Tacubaya, Federal District.

Octopterus bulleri (H. Allen),
"Southern Puebla."

Micronycteris megalotis (Gray),
Cueva de la Leona, District of Juarez, Morelos and Cuesta de Don Lino near Jalapa, Veracruz.

Hemiderma brevicaudum (Wied),
Cuesta de Don Lino near Jalapa, Veracruz.

Leptonycteris nivalis (Saussure),
"Veracruz."

Dermanura cinereum (Gervais),
Cave in Cerro Frio, hacienda of San Gabriel, District of Tetecala, Morelos.

Vampyrops helleri (Peters),
Soconusco, Chiapas.

Centurio senex (Gray),
Cerro de Los Pajaros, Las Vegas, Veracruz.

ON THE CONFORMAL REPRESENTATION OF PLANE CURVES, PARTICULARLY FOR THE CASES $p = 4, 5, and\ 6.$

CHARLOTTE E. PENGRA.

A given non-homogeneous function of x and y

$$F(\overset{n}{x}, \overset{m}{y}) = o$$

of degree n in x and m in y may, we know, be regarded either as a plane curve or as a Riemann's surface. Klein reaches a number of important results here briefly outlined by considerations based on the latter view.

Let

$$F(\overset{n}{x}, \overset{m}{y}) = o$$

be an irreducible algebraic equation defining the surface F_n which is an n-leaved surface spread over the y plane. The deficiency of the surface, p, is fixed by the number of cuts, $2p$, which is necessary to reduce F_n to a simply connected surface. The deficiency so arrived at is numerically the same as the deficiency of the plane curve

$$F(x, y) = o$$

which is precisely the number representing the number of double points which the curve lacks of having the maximum.

An algebraic function or an integral of the first or second kind belongs to a surface when it has but one value for each point on the surface, and when it has only a finite number of infinities and these only algebraic infinities of finite integral order.* Klein proves that upon F_n exist integrals of the first and second kinds. With this work as a basis the surface F_n may be conformally represented by another much simpler sur-

* See Klein Theorie der Elliptischen Modulfunctionen, Vol. I., p. 499.

face. In order to do this we must classify surfaces according to their deficiencies and treat each class separately.

In the case $p = o$ there are no cuts on the surface and no integrals of the first kind. Integrals of the second kind exist on all surfaces. Let us select one of these, w, which has a single algebraic infinity. Since there are no period paths on the surface, w assumes only one value for each point of F_n and since w has the one infinity, and only one, it is a function of "weight" one belonging to F_n where the weight of a function is defined as the number of times which it assumes the value ∞, hence the number of times which it assumes any assigned value, for points on F_n. The function w being of weight one assumes one and only one value corresponding to each point of the n-leaved surface

$$F(x, y) = o.$$

These values, real and complex, may be represented by the points in a plane by the ordinary representation of complex numbers. The given n-leaved surface can then be conformally represented upon a plane by means of the real and complex values assumed by w.

If $p = 1$ two cuts are required to make the surface simply connected. We know that on any surface of deficiency p, there exist p linearly independent integrals of the first kind. Here then there exists only one which we will call u. Let the periods across the cuts be w_1 and w_2. If u has the value u_o at a given point, for all the region around containing no branch point the u will vary continuously, and since u can be nowhere infinite, and since its values may be represented by points of a plane just as any complex number is represented, these points must all be within a parallelogram whose boundaries are determined by the limits of the values of the real and imaginary parts of u as it varies over the surface, never crossing a boundary.

If we seek then to represent our entire surface by means of the integral u which has an infinite number of values we get corresponding to a given point of F_n an infinite number of homologous points in similar parallelograms. We will form the doubly periodic functions

$$P(u \mid w_1, w_2) \text{ and } P'(u \mid w_1, w_2)$$

We know that all doubly periodic functions of u, w_1, and w_2 may be expressed rationally in terms of these two,

$$P(u \mid w_1, w_2) = \frac{1}{u^2} + \Sigma \frac{1}{(u - m_1 w_1 - m_2 w_2)^2} - \frac{1}{(m_1 w_1 + m_2 w_2)^2}$$

$$P'(u \mid w_1, w_2) = -2 \Sigma \frac{1}{(u - m_1 w_1 - m_2 w_2)^3}.$$

These two are everywhere finite except for $u = o$, where the former is infinite of the second order. Hence $P(u \mid w_1, w_2)$ is a function of weight two belonging to F_n. By means of it we can represent F_n conformally upon a two leaved Riemann's surface.

In case $p > 1$ we desire to build up a function of weight m which shall belong to the surface, by means of which the surface F_n may be conformally represented upon a simpler surface. Suppose that one such function of weight m exists on the surface and let it be represented by w and its m infinities by $y_1, y_2, y_3, \ldots\ldots y_m$. Let these infinities be of the nature

$$\frac{c_i}{y - y_i}.$$

Let

$$y_{y_1} = \frac{1}{y - y_1} - v_1 j_1 - v_2 j_2 - v_3 j_3 - \ldots\ldots - v_p j_p,$$

where the v's are the periods of w for the cuts a_i and the j's are the normal integrals of the first kind, the periods of j_k for the cuts a_i being all zero except the period for a_k which is unity, and the periods for the cuts b_i being λ_{ki},

$$w - c_1 y_{y_1} - c_2 y_{y_2} - c_3 y_{y_3} - \ldots\ldots - c_m y_{y_m}$$

is everywhere finite, the possible infinities disappearing by subtraction, and since it has periods for the $2p$ cuts, it is an integral of the first kind. Moreover, according to definition, the periods for the cuts a_i are all zeros, and therefore this integral can be put equal to a constant,* and

$$w = c_0 + c_1 y_{y_1} + c_2 y_{y_2} + c_3 y_{y_3} + \ldots\ldots + c_m y_{y_m}.$$

In order then for u to have but one value for each point on the surface, the periods across the cuts b_i must be equal to zero and

II $$c_1 \lambda_{1k} + c_2 \lambda_{2k} + c_3 \lambda_{3k} \ldots\ldots + c_m \lambda_{mk} = o.$$

If $m > p + 1$ the c's can be found and F_n can be conformally represented upon an m leaved Riemann's surface spread over the w plane by means of a function of weight m belonging to F_n.

* See Klein Theorie der Elliptischen Modulfunctionen, Vol. I., p. 524.

Let the p linearly independent integrals of the first kind of F_n be $w_1, w_2, w_3, \ldots\ldots\ldots w_p$ and their derivatives with respect to y be $\phi_1, \phi_2, \phi_3, \ldots\ldots\ldots \phi_p$. It is easy to show that the ϕ's so found are linearly independent and that any $p+1$ can be expressed linearly in terms of the other p. By expanding w in the region of the zero points, and the branch points, and then differentiating to find the value of the ϕ's we deduce the fact that the ϕ's have $2p-2$ variable zeros on F_n and $2n$ zeros at the infinite points of F_n.

This work offers an easy proof of the Riemann-Roch Theorem, for the equations (II) become in terms of the ϕ's

$$\text{III} \begin{cases} c_1\phi_1(y_1)+c_2\phi_1(y_2)+c_3\phi_1(y_3)\ldots\ldots\ldots+c_m\phi_1(y_m)=0 \\ c_1\phi_2(y_1)+c_2\phi_2(y_2)+c_3\phi_2(y_3\ldots\ldots\ldots+c_m\phi_2(y_m)=0 \\ \quad\vdots\qquad\qquad\vdots \\ c_1\phi_p(y_1)+c_2\phi_p(y_2)+c_3\phi_p(y_3)\ldots\ldots\ldots+c_m\phi_p(y_m)=0 \end{cases}$$

$$\text{since } \lambda_k = -2\pi i \left(\frac{dk_j}{dy}\right)^*_{y=y_0}$$

If τ of these equations are dependent upon the rest it is possible to combine the other $p-\tau$ in such a manner as to get these dependent ones, and indeed to get τ equations which shall be linear in the ϕ's and which vanish in all the points $y_1, y_2, y_3, \ldots\ldots\ldots y_m$, which proves that there are τ linearly independent functions which vanish in all the points $y_1, y_2, y_3, \ldots\ldots\ldots y_m$.

By solving the system (III) we can express $p-\tau$ of the c's in terms of the other $m-p+\tau$. These $m-p+\tau$ variables enable us to fix the totality of algebraic functions belonging to F_n which are of weight m or less. The most general function of weight m belonging to F_n contains in general $m-p+\tau+1$ arbitrary constants.

The Riemann-Roch Theorem so proved would hold only for $p > 1$. Klein extends it to the cases $p = 0$ and $p = 1$. He constructs a function

$$w = c_0 + \frac{c_1}{w-w_1} + \frac{c_2}{w-w_2} + \ldots\ldots\ldots + \frac{c_m}{w-w_m}$$

which is evidently a function of weight m belonging to the surface. Since there are no ϕ's, $\tau = 0$ and the number of arbitrary

* See Klein Theorie der Elliptischen Modulfunctionen, Vol. I., p. 532.

constants is $m+1$, which is the number which the Riemann-Roch Theorem would give. Similarly for $p=1$ one ϕ function exists and one equation of the set (III) $\tau = o$ and the Riemann-Roch Theorem holds here also.

To take up the language of the analytic geometry, we have selected a complete set of linearly independent functions each of weight m belonging to F_n and we use these as co-ordinates, this fixing some sort of curve. Every point of F_n gives rise to a set of values of these functions, or to a point, hence the whole surface F_n may be conformally represented by the points of some curve. The functions which we select for this purpose are the ϕ's of which there are p linearly independent. Their ratios are functions belonging to the surface for they have only a finite number of infinities and these algebraic, and the ratios have one and only one value corresponding to each point of F_n. For if one of them, say $\frac{\phi_1}{\phi_2}$ assumed the same value for two different points of F_n, we should have a relation existing among the coefficients of ϕ_1 and ϕ_2, but by hypothesis the ϕ's are independent and hence their ratios belong to the surface F_n. Since, as before shown, each ϕ becomes zero in $2p-2$ variable points of F_n, each ratio may become ∞ in $2p-2$ points, and zero in as many more, and hence the functions which are ratios of the ϕ's are of weight $2p-2$.

Although the ϕ's are linearly independent certain relations of higher order exist among them. For the case $p=o$, no ϕ function exists and F_n, as we saw, is representable by the points of a plane singly covered, or if we consider only the real points, by the points of a straight line.

For $p=1$ one ϕ function exists. We found that the simplest function which will represent F_n in this case is a function $P(u \mid w_1\ w_2)$ of weight two. According to the Riemann-Roch Theorem there are $m-p+\tau+1$ or two homogeneous arbitrary constants in our representative function. Hence, since it is represented on a two-leaved Riemann's surface, in the language of curves the simplest representation of $F(x, y) = o$ is a doubly covered straight line.

For $p=2$ two ϕ curves exist. Our normal curve then is a doubly covered straight line since it exists in space of one dimension and the ratio of the ϕ's is a two valued function. No relation can exist between the ϕ's.

For $p=3$ one quartic relation exists among the ϕ's so that our normal curve is a plain quartic. For we know from the Riemann-Roch Theorem that the most general quartic relation among the ϕ's contains $4(2p-2)-p+\tau+1=14$ arbitrary constants which are just enough to give the most general quartic relation among the ϕ's since if we write out a quartic relation it will contain fifteen terms and by a selection of the fourteen arbitrary constants the function is completely fixed.

For $p=4$ two relations of higher order exist, one of the second degree and one of the third degree. This may be proved as follows: We write out all the homogeneous functions of the second degree obtained by taking the squares of the different ϕ's and their products taken two at a time. Divide each of these by some homogeneous function of the second degree in the ϕ's. According to Riemann such functions like branched on a surface T can be expressed linearly in terms of $3p-2$ of them which make $3p-3$ linearly independent ones. There are $\frac{p(p+1)}{2}$ different combinations of the ϕ's mentioned above and these can be expressed in terms of $3p-3$ independent ones, so there must exist at least $\frac{p(p+1)}{2}-(3p-3)$ or $\frac{(p-2)(p-3)}{2}$ quadratic relations among the ϕs. Similarly there are $\frac{p(p+1)(p+2)}{6}$ combinations of the ϕ's of the third degree. Divide each of these combinations by the same cubic relation among the ϕ's. of these quotients $5(p-1)$ are independent of each other.* There must exist then at least $\frac{p(p+1)(p+2)}{6}-5(p-1)$ cubic relations among them. But we know from the preceding that there are at least $\frac{(p-2)(p-3)}{2}$ quadratic relations among the ϕ's. Cubic relations among the ϕ's could consist of these quadratic relations multiplied by any one of p linearly independent equations of the first degree among the ϕ's. To get the number of cubic relations which do not break up thus we shall have to

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*Jahresbericht der Deutschen Mathematiker Vereinigung, Vol. III. p. 445. Math. Ann. Vol. XII, pp. 268-310.

subtract these $\frac{p(p-2)(p-3)}{2}$ from the number previously arrived at. There are therefore at least

$$\frac{p(p+1)(p+2)}{6} - 5(p-1) - \frac{p(p-2)(p-3)}{2} \text{ or}$$

$$\frac{-p^3+9p^2-23p+15}{3}$$

cubic relations among the ϕ's independent of the quadratic relations. This result is in accordance with Weber for the case $p=4$,* and it does not contradict Noether's statement that there are $\frac{p(p+1)(p+2)}{6} - 5(p-1)$ since I say that there are at least $\frac{-p^3+9p^2-23p+15}{3}$, my formula always giving a smaller number than his.

If $p=4$ we select two functions belonging to the surface, one of weight twelve, the other of weight eighteen, the former of degree two, the latter of degree three in the ϕ's. For the normal curve representing $F(x,y)=o$ we have then a twisted sextic in space of three dimensions and defined by the intersection of these surfaces of second and third degree respectively in the ϕ's. Conversely, any twisted sextic which is the intersection of such surfaces is the normal curve of some $F(x, y)=o$ of deficiency four. For at some point of the common intersection pass a plane tangent to the quadratic surface. It will cut the quadratic in two straight lines real or imaginary, and the cubic surface in a plane cubic. The lines each meet the cubic twice beside the original point. Projecting the twisted sextic from the original point on a plane we get a quintic with two double points which is a curve of deficiency 4 and hence the proposition is proved.

If the quadric surface is an ellipsoid, by projecting the twisted sextic from the highest point the quintic obtained will have no infinite points. Its double points will be the projection of one real and one imaginary point of the sextic, and hence will look like an ordinary point on the curve. If the quadric be a cone one of the double points of the quintic may be real and if the surface be an hyperboloid or paraboloid both double points of the quintic may be real. If the quadric become a cone, by

* Math. Ann., Vol. XIII, p. 47.

projecting the twisted sextic from the vertex of the cone we get a conic three times repeated since each generator of the cone will cut the sextic in three points. This case is referred to later.

Noether has published some work in Vol. 26 of the Mathematische Annalen in which he actually works out the relations which may exist among the ϕ's for the cases $p = 5$, 6 and 7. Käsböhrer has a dissertation on the case $p = 8$.

If $p = 5$ our function of the second degree in the ϕ's contains fifteen homogeneous linear constants. According to the Riemann-Roch Theorem it should contain only $16 - 5 + 1 = 12$ When we fix these twelve there are left then three more, homogeneous and linear. So we see the three linearly independent quadratic relations among the ϕ's. The normal curve in this case is a twisted curve of eighth degree in space of four dimensions. Weber proves* that if we take any three homogeneous functions of degree two in the ϕ's and eliminate two of the variables we shall get a curve of deficiency five, thus proving that any twisted curve of degree eight formed by the intersection of three quadrics in space of four dimensions, represents a $F(x, y) = o$ of deficiency five.

It is very easy to get some properties of curves of higher order out of the properties of the normal curves. To illustrate this take the case $p = 3$ where the normal curve is, as we know, a quartic with no double points. We will prove that a curve of order n and deficiency three may be regarded as the envelope of sixty-three different quadratic sheaves of curves of order $2(n-3.)$ Six in each set break up into two curves each of order $n-3$ which pass through all of the double points of the curve of the *nth* degree and have their other intersection on a curve of degree $2(n-3)$. In particular a sextic of deficiency three possesses 28 tangent cubics which pass through the double points of the sextic and such that they can be arranged into sixty-three sets of twelve each, such that the points of intersection of corresponding cubics in each set shall lie on a curve of order six having the same double points as the original sextic. For if we transform a given curve of deficiency three and order n by means of a net of adjoint curves of order $n-3$ we get a quartic of defiency three and to the adjoints correspond straight lines. We know that such a quartic has

* Math. Ann., Vol. XIII, p. 44.

twenty-eight bitangents which may be divided into sixty-three sets of twelve each such that the points of intersection of corresponding pairs lie on a conic. This quartic may be regarded as being the envelope of sixteen different quadratic sheaves of conics — each sheaf containing six conics which break up into two straight lines, forming a Steiner complex. Moreover all of these double points lie on the Jacobian of the net to which all of the sheaves belong, this Jacobian being of order six. The proposition then follows as the result of the correspondence bethe curve and the *nth* degree and the quartic.

Another illustration is here taken from the case $p = 4$. We will prove that there are twenty-seven different pairs of points on a curve of degree n and deficiency four which can be taken in sets of three in forty-five different ways to lie on as many adjoint ϕ functions of the original function.

For in this case the normal curve is the twisted sextic — the intersection of a quadric with a cubic surface. We know that through any straight line on a cubic surface can be passed five planes each of which cuts the surface in two or more lines, so that each line is intersected by ten others — eight outside a plane containing three of them.

Considering then three lines in a plane and the eight lines which cut each, we have twenty-seven lines in all. Each line intersects the quadric surface in two points thus giving two points of the normal curve. There are, therefore, fifty-four different points on the twisted sextic such that they lie by sixes in forty-five different planes since the twenty-seven lines lie by threes in forty-five different planes. Carried over by transformation to a curve of order n we get the proposition above.

In the work hitherto, we have been considering the curves represented as perfectly general. We will now examine some special cases. In order to do this we take up some θ functions.

In $$\theta(v_1, v_2, v_3, \ldots v_p) = \sum_{-\infty}^{\infty} e^{\pi i(an^2 + 2nv)}$$

let an^2 be a complete quadratic function of the n's and n a complete linear function of the v's of which there are p. We will now put for the a's the period moduli of the normal integrals

* Salmon's Geometry of Three Dimensions, p. 769.

along the cuts a_i of a surface T defined by $F_n = o$ and of deficiency p. We will put for the v's the normal integrals diminished each by a constant e. We shall then have

$$\theta(v_1, v_2, v_3 \ldots . v_\rho) = \theta \sum_1^p h \int_\varepsilon^\varphi du_h - e_h$$

where the φ's and ϵ's are arbitrary points and φ's are variable.

These integrals of the first kind exist in the original surface F_n and therefore this θ function is like branched with the surface. If it does not vanish identically we know from the properties of θ functions that it has p zeros on the surface. If however, this θ function does vanish identically one or more of these zeros become arbitrary.

Suppose that the e's are so chosen that θ is different from zero.

Then
$$e_h \equiv \sum_{i=1}^{i=p} \int_{\varepsilon_i}^{x_i} du_h + k_h,$$

where x_i are zero points of the θ function and k_h is independpendent of e_h. If moreover, the e's are so chosen that

$$\theta(e_1, e_2, \ldots . e_p) = 0,$$

then
$$\theta(v_1, v_2, \ldots . v_p) = 0,$$

and for an arbitrary point and we put

$$e_h = \sum_{i=1}^{i=p-1} \int_{\varepsilon_i}^{x_i} du_h + k_h \qquad -e_h \equiv \sum_{i=1}^{i=p-1} \int_{\varepsilon_i}^{x'_i} du_h + k_h$$

where the point systems x_i and x'_i belong to an equation $\phi = o$ besides lying on the surface $F_n = o$. The quotient of the product

$$\theta\left(\sum_1^p h \int_\epsilon^x du_h - e_h\right) \times \theta\left(\sum_1^p h \int_\epsilon^x du_h + e_h\right)$$

and the product

$$\theta\left(\sum_1^p h \int_\epsilon^x du_h - f_h\right) \times \theta\left(\sum_1^p h \int_\epsilon^x du_h + f_h\right)$$

may be put equal to $\frac{\phi_1}{\phi_2}$, ϕ_1 and ϕ_2 each having like branches with the original function. $\frac{\phi_1}{\phi_2}$ is a function of weight $2p-2$ since it is zero in $2p-2$ variable points and ∞ in as many. The ϕ's are then adjoint curves of the original function and are of order $n-3$.

Introducing the θ functions with characteristics we know that there are $2^{p-1}(2^p-1)$ odd theta functions and $2^{p-1}(2^p+1)$ even theta functions. In general only the odd theta functions vanish for the zero values of the arguments.* If we assume now that $e_h \equiv -e_h$ and $f_h \equiv -f_h$ we get the zeros of our function before considered to fall together in pairs and there exist $p-1$ points at which the ϕ's are zero of order two. $\sqrt{\phi}$ is an Abelian function and there are $2^{p-1}(2^p \pm 1)$ of these together, one for each different characteristic. In the case of the odd theta functions there are $2^{p-1}(2^p-1)$ ϕ curves tangent to the original curve.

Let us make the assumption that up to any number m our function

$$\theta\left(\sum_{l}^{p} h \int_{\epsilon_i}^{\sum_{i=1}^{i=m-1} x_i} du_h \pm \frac{w_h}{2}\right)$$

vanishes identically for all the points, $x_1, x_2, \ldots\ldots x_{m-1}$ and

$$\theta\left(\sum_{l}^{p} h \int_{\epsilon_i}^{\sum_{i=m}^{i=m-l} x_i} du_h \pm \frac{w_h}{2}\right)$$

does not vanish.

According to Riemann's work before referred to, the condition is that

$$\theta[w](v_1, v_2, -\ldots\ldots v_p)$$

with all its derivatives up to and including the $(m-1)st$ but not all the mth derivatives must vanish for the zero value of the arguments.

*Ueber das Verschwinden der Theta Functionen, Riemann's Werke, p. 198.

The functions

$$\theta\left(\begin{matrix}p\\ h\\ 1\end{matrix}\int_{\varepsilon}^{x} du_h - \sum_{i=1}^{i=m-1}\int_{\varepsilon_i}^{x_i} du_h - \frac{w_h}{2}\right), \text{ and}$$

$$\theta\left(\begin{matrix}p\\ h\\ 1\end{matrix}\int_{\varepsilon_i}^{x} du_h + \sum_{i=1}^{i=m-2}\int_{\varepsilon_i}^{x_i} + \frac{w_h}{2}\right)$$

will not vanish identically for the points x_i, ϵ_i, taken arbitrarily, and therefore each of them will vanish in $p-1$ points beside ϵ and both together in $2p-2$ points on a function ϕ. Now among the zeros of the first functions are $x_1, x_2 \ldots\ldots x_{m-1}$ and let the rest be $y_m, y_{m+1} \ldots\ldots y_{p-1}$ and let the zeros of the second one be $a_1, a_2, a_3, \ldots a_{m-1}, \beta_m, \beta_{m+1}, \ldots\ldots \beta_{p-1}$. There exists then a function ϕ with the zeros $x_1, x_2, \ldots. x_{m-1}, y_m, y_{m+1}, \text{——} y_{p-1}, a_1, a_2, \ldots. a_{m-1}, \beta_m \beta_{m+1}, \ldots. \beta_{p-1}$.

Moreover since the zeros must satisfy the congruences

$$(e_1, e_2, \ldots. e_p) \equiv \left[\begin{matrix}p\\ h\\ 1\end{matrix}\left(\int_{\varepsilon_1}^{x_1} du_1 + \int_{\varepsilon_2}^{x_2} du_2 \ldots \int_{\varepsilon_h}^{x_h} du_h + k_h\right)\right]$$

$$\left(\frac{v_2}{2}, \frac{w_2}{2} \ldots \frac{w_p}{2}\right) = \left[\begin{matrix}p\\ h\\ 1\end{matrix}\sum_{i=1}^{i=m-1}\int_{v_i}^{x_i} du_h + \sum_{i=p-1}^{i=m}\int_{\varepsilon_i}^{y_i} du_h + k_h\right]$$

$$\left(-\frac{w_2}{2}, -\frac{w_2}{2} \ldots -\frac{w_p}{2}\right) = \left[\begin{matrix}p\\ h\\ 1\end{matrix}\sum_{i=1}^{i=m-1}\int_{\varepsilon_i}^{a_i} du_h + \sum_{i=p-1}^{i=m}\int_{\varepsilon_i}^{\beta_i} du_h + k_h\right]$$

Combining the last two by substraction we obtain

$$\begin{matrix}p\\ h\\ 1\end{matrix}\sum_{i=1}^{i=m-1}\int_{x_i}^{a_i} du_h + \sum_{i=p-1}^{i=m}\int_{y_i}^{\beta_i} du_h \equiv 0$$

It follows from Abel's theorem that there exists a rational function ϕ which is infinitely small of the first order at the

points α_i β_i and infinitely great of the first order at the points x_i y_i and otherwise continuous and different from zero. This function is expressible as the quotient of two functions ϕ. But since there is a function ϕ which vanishes in all the $2p-2$ points we have the two functions $\tau\,\phi=\phi_1$ and $\frac{\phi}{\tau}=\phi_2$ the first infinitely small of the second order in the points

$$x_1, x_2, x_3 \ldots\ldots x_{m-1}, y_{m+1}, \ldots\ldots y_{p-1},$$

the second infinitely small of the second order in the points.

$$\alpha_1, \alpha_2, \alpha_3, \ldots\ldots \alpha_{m-1}, \beta_m, \beta_{m+1}, \beta_{m+2}, \ldots\ldots \beta_{p-1}.$$

These functions are then squares of Abelian functions. Eliminating τ we obtain $\sqrt{\phi_1\,\phi_2} = \phi$ or $\phi_1\,\phi_2 = \phi^2$.

If we choose the points x_i otherwise we obtain an arbitrary number of Abelian functions $\sqrt{\phi_1}$, $\sqrt{\phi_2}$, etc., which have the property that the square root of the product of two of them is again an Abelian function. Since $m-1$ zeros are arbitrary we get m linearly independent ϕ's of this sort.

I wish now to examine some special cases which arise here in the vanishing of the θ functions. For surfaces of deficiency 0, 1 or 2 no such relations can exist. For the case $p=3$ there are three linearly independent ϕ's. Ordinarily as we have seen no relation exists among them of lower degree than the fourth. The normal curve in the general case is a quartic which is fixed when we stipulate that it shall be a function belonging to the surface defined by the original equation, and fix its infinities.

If now an even θ function belonging to the surface vanishes identically we get, as we have seen, the relation

$$\phi_1\,\phi_2 - \phi^2 = 0$$

We may regard this as the formal curve and, for the sake of continuity, say that it is doubly covered, thus our quartic relation degenerates into two identical equations of the second degree and the normal curve is a conic doubly covered. This equation may be put into the form

$$(\lambda^2\phi_1 + 2\lambda\phi_2 + \phi)(\mu_2\phi_1 + 2\mu\phi_2 + \phi) - [\lambda\mu\phi_1 + (\lambda+\mu)\phi_2 + \phi]^2 = 0$$

thus showing up the tangent lines if we regard the ϕ's as coordinates, In the case then that an even θ function vanishes

identically the normal curve is such that it has an infinite number of tangent ϕ curves. Any curve then of the same deficiency, in case the even theta function vanishes identically, has an infinite number of tangent ϕ curves. In particular the sextic of deficiency 3 can be put into the form

$$(\lambda_2\phi+2\lambda\phi_2+\phi_3)\,(\lambda^2\mu\phi_1+2\mu\phi_2+\phi_3)-(\lambda\mu\phi,+(\lambda+\mu)\phi_2+\phi_3)^2=0$$

thus showing the sextic as the envelope of a quadratic sheaf of adjoint curves of order three. Conversely if we get any sort of a quadratic relation among the ϕ's in the case $p=3$ an even theta function most vanish identically, for we can construct a system of such Abelian functions by putting the conic in the form $L_1L_2-L_3^2=o$ and Weber has proved* that if such a system can be constructed linearly and homogeneously from m independent Abelian functions then there can be found a characteristic w possessing the property that the function $\theta\,[w]$ together with all its derivatives up to and including those of order $m-1$ must vanish identically.

In case then that one quadratic relation exists among the ϕs for $p=3$ the normal curve is a doubly covered conic and the case is hyperelliptic.

For $p=4$ suppose that one even θ function vanishes identically. We then get the relation

$$\phi_1\phi_3-\phi_2^2=o$$

For a general curve of deficiency four the normal curve is, as we know, a twisted sextic made by the intersection of a quadric surface with a cubic surface. Now with the vanishing of the θ functions the quadric surface becomes a cone and the representation is characterized by the fact that the tangent ϕ curves to the original curve correspond to the planes tangent to the cone, and so to the points of tangency of ϕ curves correspond three points on the generator of a cone. The normal curve is a twisted sextic such that it has a G_3^1 or a singly infinite system of points three in a set, such that each group of three lies in a straight line.

Suppose another quadratic relation to exist among the ϕ s. This means that the quadratic relation as determined to represent the surface F_n contains a variable parameter by

* Weber in Vol. XIII, Math. Ann., pp. 34-38.

means of which the quadric can be expressed as a cone in four different ways. Our normal curve, the twisted sextic, must lie on both quadric surfaces as well as on the cubic surface. Hence it degenerates into a twisted cubic twice repeated. The two cones being evidently of the form

$$\phi_1\phi_2-\phi_3^2=0$$

$$\phi_4(F_1(\phi's)]-[F_2(\phi's)]^2=0$$

containing a straight line in common. This gives the hyperelliptic case for $p=4$.

For the case $p=5$ we know that there exist three quadratic relations among the ϕ's. Let one of these give a cone in space of four dimensions. To the infinite number of ϕ curves which are tangent to the original curve at one point correspond the infinite number of three flats tangent to the cone, and to the point of tangency correspond the four points of the normal curve found on each of the planes along which the three flats are tangent to the cone. The normal curve, which is a twisted curve of eighth order in space of four dimensions, is characterized in this way by a G_4^1 of points lying on a plane.

If two of the three quadrics are cones the normal has two G_4^1's and for three cones three G_4^1's.

If four quadratic relations exist the case is hyperelliptic.

In conclusion, I wish to acknowledge the kindness of all the Professors of Mathematics at Wisconsin, and particularly my indebtedness to Dr. Dowling for his valuable suggestions and assistance in connection with the preparation of this paper.

University of Wisconsin, July 14, 1903.

MEMORIAL ADDRESSES.

PRESIDENT CHARLES KENDALL ADAMS.

For the presidency of the University of Wisconsin, which was doubtless the most important work of his life, Dr. Charles Kendall Adams was peculiarly fitted by circumstances as well as training. Born in Vermont Jan. 24, 1835, of a family that was old, but, like the typical New England farm, poor, he had in his boyhood meager opportunities for study, in summer working on the farm, in winter first attending and later teaching district schools. But he was always eager to learn, and his brother used to tell how with a book on his plow he sometimes let his beast make a furrow at its will till aroused from his preoccupation. Perhaps it was significant that this youth who was after a while to become a torch-bearer of learning started West carrying in his hand a copy of Shakespeare which had been overlooked in the packing up. Having migrated to Iowa in 1855 he began to study Latin and Greek after his 21st birthday, and entered the University of Michigan in 1857.

He entered from a private academy after hurried preparation, and gave me long afterwards the impression that only kindly leniency on the part of his examiners let him into the university. It was only necessary to get in "by the skin of his teeth;" ability, zeal, and industry did the rest. I have heard him say that only the helpful human sympathy of Professor Boise on his first recitation encouraged him to hold up his head after that first failure. Doubtless this encouragement, that never failed afterwards, made the man, and how grateful he always was to Boise! Perhaps even his lifelong partiality for Greek studies was due to that. He worked his way through college by manual labor and service in the library, but found time to read as well as to work and study, for in his freshman

year—as he said once to the students of the University of Wisconsin—he saved money enough to buy a dozen good books in general literature, and read them.

Graduated in 1861, he went on to the Master's degree in 1862, was then appointed instructor in Latin and history, assistant professor of history in 1863, and in 1867 full professor of history, with the privilege of spending a year and a half in German and French universities. The man he succeeded in the chair of history was the then young Andrew D. White, who had perhaps chiefly influenced his student career, determined his choice of a specialty, nominated him for his own chair on leaving, suggested him, I think, as his successor in the presidency of Cornell, and remained all through life his closest friend. Connected with the University of Michigan twenty-eight years—five as student, twenty-three as member of the faculty—he came to be regarded perhaps as its most eminent professor, and was dean of the school of political science from its establishment in 1881. First, as non-resident lecturer on history at Cornell (1881–5), and later as president (1885–92), he became thoroughly familiar with that Eastern institution which is doubtless most nearly of the style of the Western state university. He had been chairman, too, of the building committees of the great libraries of the University of Michigan and of Cornell, something significant in view of his later connection with that beautiful structure which will remain as his chief monument at Madison—the Historical Library. At the age of fifty-seven, in the maturity of his powers, learning, and experience in affairs, he came in the autumn of 1892 to the University of Wisconsin.

A paragraph from a paper which I prepared for local use at the time of his resignation last autumn sums up some of the qualities of the man as well as the striking results of his nine years' administration: "Dr. Bascom's thirteen-year administration had put the young institution on a sound basis of scholarship, had filled the state with a fine body of alumni loyal to their president and fond of their alma mater, and had made inevitable and easy the transition from a small college to a big university. Dr. Chamberlin's five-year regime had been marked by greatly accelerated growth in numbers and development of university temper and spirit. The latter found Science Hall built, and he began and all but finished the Dairy

Building, Law Building, and Gymnasium. The legislatures of 1889 and 1891 had made notable and noble appropriations. In 1893, $140,000 was added, making possible the adequate completion and outfit of the edifices already under construction. In 1895 came the phenomenal appropriation—one-fifth of a mill tax additional (i. e., interest on $2,000,000) for two years, and $180,000 for the Historical Library.

"In 1897 the one-fifth mill tax was made permanent and the amount for the Historical Library was increased to $420,000; in 1899 $135,000 was appropriated for a new Engineering Building and for the agricultural heating plant and to complete and equip the Historical Library $200,000 more. In 1901 about $200,000 was appropriated, of which $150,000 was to go to the construction of Agricultural Hall, the remainder to the general university fund and to engineering improvements. From 1890 to 1900 was the building era of the university. * * * The increase of the students and faculty has been quite commensurate with the improvements in building. In 1892 the number of students was 1,092, now 2,800; of instructors, and other officers in 1892, 73; now, 168. * * * He is a man of fine presence and distinguished bearing, affable, a good conversationalist, has for many years been given to entertaining notable people, and so, while utterly unassuming, has the air of one who is at home in the best company. People who do not know him well have sometimes called him an aristocrat. On the platform he never makes a poor speech, and sometimes a great one. As presiding officer at a banquet he has few equals within my knowledge. In social matters his administration has been a pronounced success. * * * But he is also a great executive officer. I have heard him say that American people do big things better than they do little ones. Lesser men can turn off routine business quite as well as he; his pre-eminence is in planning and accomplishing large things.

"The best evidence of this outwardly is the great Historical Library; the best proof of it inwardly is the vast extension of facilities, not simply to meet the great increase in the number of students, but to make possible the most advanced work and to cause the ablest men to feel that Wisconsin is the best place to stay and labor in. Some of the newspapers have criticised sharply at times, and some legislators have come from the people to make a fight; but in the end the majority of the legisla-

ture and of the people have come over to his ideas and his ideals, and civic pride in the university has enormously increased. The friction which a few years ago existed between the authorities of the lower schools and the university seems now to have disappeared entirely, and a cordial and helpful relation has taken its place."

President Adams was passionately loyal to and enthusiastically confident of the great future of the University of Wisconsin. He showed remarkable capacity in choosing members of the faculty as well as in uniting and harmonizing them in the common work, fostered and stimulated the spirit of research among the instructors, and yet would remind them that "the university is for the students," whose instruction should not be sacrificed to investigation. His zeal for athletics came mainly from the conviction that a maximum of clear and sane thinking as well as the most moral living is not to be expected from men in poor health. His manifest and well known sympathy with all that made for real religion in the university was but the outward expression of inward belief and consistent home living.

An estimate of the service rendered by President Adams to the university and to the cause of higher education, made by Dr. Birge at the time of his resignation, pleased President Adams above all appreciations then made public. It is as follows:

"President Adams was one of the first men in this country to catch the spirit and temper of true university study and administration. This spirit he embodied, first, in his own teaching, and this temper, as larger opportunities were afforded him, he carried into the institutions of which he has been the head. The university temper expresses itself, when it is present, in every department of university work from the freshman classes to the graduate courses. It was by no means absent from our University in the years before 1892, yet it has received a mighty impulse and stimulus from the example and teachings of President Adams. This internal growth, this development of a higher standard of scholarship in the university, has been President Adams' great contribution to the intellectual life of the state. By a higher standard of scholarship I do not mean the exaction of more work from the student or the mere 'raising of the standard' in the technical sense, but a lifting of the insti-

tution to a truer and higher intellectual position. This is the greatest service that a president can render to his university, and this President Adams has fully rendered to us. To this end all his measures have tended. In carrying out this main purpose, President Adams has shown great breadth and largeness of view. He has been able to conceive large plans for the university, which he has boldly executed. Yet he has never striven to enforce his own ideas upon the various departments, aiming rather to inspire unity and harmony of spirit and purpose than to secure a similarity in method. Thus he has been able to win and hold the sympathy of the faculty for his plans and their co-operation in working them out and applying them in the administration and the teaching of the university."

President Adams was stricken down about February 1, 1900, and was never at the helm for more than a day or two at a time after that. After weeks of suffering at home he was sent by his physicians, first to Virginia, then to Battle Creek, Mich., and finally for a year to Italy and Germany. During all that period I was in constant correspondence with him, and some extracts from his letters may be used to illustrate his absorbing devotion to the university, and to indicate some of his plans and ideals in educational work. He was trying to get well for the sake of the work he felt he had still to do at Madison, and every movement for a year and a half was determined by that. He abandoned a contemplated trip from Italy to Egypt, "for the reasons," he wrote, "of the twofold fact of my continued improvement and the opinion of the doctor that I should probably not return from Egypt as well as I might be on going. I hope that in the spring we may go to Athens and, perhaps, to Sicily."

By January 1, 1901, he had reached his normal weight again and the physician who had accompanied him from Battle Creek returned home, saying that it was "absurd for him to remain longer." "I should call myself entirely well," he wrote, "but for a little nervous weakness, which, I suppose, is the last remnant of the illness." Nature just then was in sympathy with their returning health. "The climate here is charming," he wrote. "Roses, heliotropes and oleanders seem not to know any such thing as winter. Their blossoms are now upon every wall and along every roadside. Today we sat with our windows wide open to the floor, and many have sat among the flowers in the garden." "What a country it is!" he wrote again

in February. "As I write at midday we are having the third concert under the window—not the hand organ, which seems to be good enough only for America—but by a violin and a singer, both fit for the stage. There are tears and laughter and exultation, all expressed with the fire of an operatic training. Of such concerts we must have about five a day, and, strangely enough, do not quite tire of them. There is a picturesqueness about the whole matter that is almost bewitching."

Some extracts from letters of that period illustrate one of President Adams' abiding interests in matters of higher education, i. e., classical studies. When urging me to come to Madison in 1894, he said that in a college course one language at least was especially deserving of favor as embodying and representing pure culture of the highest kind, and that language to his mind had always been the Greek. "I invite you to a larger field, and it is your duty to come," he said with great emphasis; and I was practically won at once. Some time later Dr. B. I. Wheeler wrote me: "President Adams will give the most earnest support. You will find him a loyal, sound, wise man." During the eight years that followed I found his zeal for classical studies always unabated. The last thing he did for the university was to organize the school of commerce and it might have seemed that he, too, was swamped by the wave of commercialism that was sweeping over the country. But he sent Dean Johnson of the college of engineering, his chief agent in the new venture, to consult with me, and called me to his sick bed to say that "he did not want some of us who stood for ideal things to think that the university was to be wholly given over to the material and practical." And a year later he wrote me from Italy (March 22, 1901): "I note all you say in regard to its being a technical year. But I want the university not to be swamped by a spirit of commercialism. Every interest should be encouraged. What men have accomplished is quite as important as what they are accomplishing."

In 1894 he had led me to hope that we might have some day at the University of Wisconsin a classical museum, and this matter was much on his mind when he was abroad—without any urging from me, it may be said, for I never found it necessary to remind him of promises. February 7, 1901, he said in a postscript to a letter: "I came within an inch of forgetting one of my errands in writing. Before I left Madison I asked the

regents to allow me to use the balance of my salary, i. e., what was really saved by my absence, in the purchase of plaster casts for a classical museum in the new library building. The answer was that I must not trouble myself with anything of the kind till I was really well. In so far as this was prompted by a consideration for me, I appreciated it, and of course there was no answer to give. But the time has come when no such answer suffices. All the manufactories in the world are glad to decorate Johnson's building [Engineering Hall]; but Socrates and Demosthenes can't send their photographs, nor can Phidias send his architectural designs. Consequently such things either have to be bought, or we are in danger of being snowed completely under by a spirit of commercialism. Carnegie and Rockefeller will perish, but there are some others that will remain. I recently wrote —— that I should be greatly disappointed if I were not permitted to make the expenditures. If I could spend, say, $1,000 for photographs and $2,500, or such a matter, for statuary, my illness will not have been without advantage."

Meanwhile a change had taken place. Winter came suddenly; Mrs. Adams was stricken down with asthma; her illness was long and his sympathy intense, so that he was never quite so well again. Still he maintained the struggle for health. Seven months later, when, under the impression that his health was far better than it was, I had urged his being here to meet the board of regents in September, he replied: "Ever since January 5 we have been fighting the battle to get into condition to resume work at the beginning of the year. In the case of my wife the battle cannot be said to have been successful—at least the improvement has been so capricious and slow that up to the arrival of your letter it seemed uncertain what the true course should be. I have been confronted with the dilemma of either going back without her or delaying the voyage in the hope of further improvement. I have too much dread of an avenging Nemesis to undertake the former course." They decided to come home together, and that last letter from Germany concluded thus: "Of one thing I wish to assure you. Every movement, except my shortest possible journey to Glasgow, has been dictated by considerations of health. * * * It has, beyond all question, been the most anxious and disappointing year of my life. In spite of all these facts I shall attempt to be present at the meeting of the board."

The provision in his last will and testament directing that five of the fifteen five-hundred dollar fellowships, to the establishment of which he devoted his entire estate, should go to the department of Greek is the final proof of his belief in the value of Greek culture.

He and Mrs. Adams reached Madison in September in time for the meeting of the board. Dean Johnson, Mr. Hiestand, and I met them at the station. Waiting by the car for them to get off, I said to Mr. Hiestand, as I heard the President's voice, "It has the old ring!" But when his face appeared, I was shocked to see how he had aged in a single year. That was Saturday night. The next morning he telephoned me to come and dine with him and Mrs. Adams. When I went at noon I found he had already been conferring with Dean Henry about Professor F. H. King's call to Washington. With such vigor he instantly resumed his duties. He felt equal to and eager for the accustomed burdens. "I could run two universities!" he said to Mr. Stevens. But he was apprehensive about Mrs. Adams.

The first severe test of his powers came shortly—the opening Convocation address to the students, an occasion to which he had been looking forward for months. The meeting was held in the Armory, and he spoke for forty-five minutes connectedly, clearly, and logically. It was a good speech, but it seems he came through by sheer force of will. He looked somewhat dazed at the conclusion, but I felt no uneasiness at the moment. But his wife's womanly instinct divined instantly what had happened, for as he approached the house she said she knew it was all over. Under the first severe strain he had broken down. Serious illness followed and the old trouble returned. As soon as the regents could be got together he resigned. The night before the resignation was formally laid before the board he telephoned for me to come and told me what he had done. Tears fell as he spoke, and he looked a gray and aged and broken man. It was very hard. He had hoped to serve the university till he was seventy-five, nine years longer, and he had great plans for it. Now it was all over. I knew his heart was broken, but he did not murmur. When a few weeks later his train had started for California, and Dr. Birge and I turned homeward, I said, "We shall see his face no more!"

His last letter to me is pathetic, in view of what happened so

shortly after. "We are beginning to get ready to move into the new house," he wrote, June 21. "Probably in two weeks we shall be in our own home. My wife looks forward with great pleasure to the new life, and I hope it will be in every way beneficial. * * * Neither of us is in the best condition." Early in July they moved into the new house they had built, and on the 26th he passed away.

In one of his later letters there is a reference to the book of resolutions—with signatures of all the faculty—prepared in consequence of his resignation, and with that I may close: "The Cardinal book touched me so deeply I have hardly dared to venture on a formal acknowledgment; but I must do so without much delay. Especially gratifying was the note preceding the signatures themselves. As a whole I believe the work to be unique. Surely our dear old Patrick (janitor) would have called it a 'wonderful char-ac-ter from me last place!' God bless you all!"

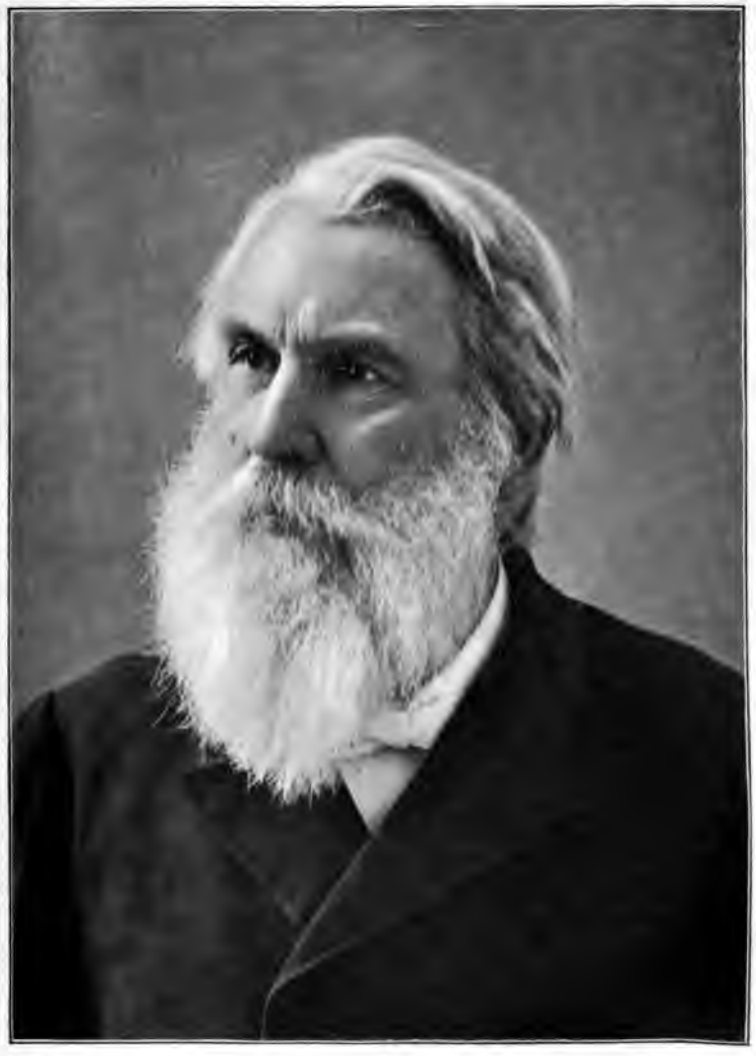
CHARLES FORSTER SMITH.

DR. GEORGE McKENDREE STEELE.

In comparatively inconspicuous positions there have often been princes. Some men are great enough to do large work in humble fields. Usually the place surpasses the man, but sometimes the man, relatively speaking, surpasses the place. Such seems to have been the case with George McKendree Steele to whose life and service we are today to pay respect.

Dr. Steele was built on a large scale. Physically, he stood Achilles like among men. His stalwart frame was full of rugged strength. Of his leonine head, President Warren of Boston University has said, "Surrounded with a diadem it would have reminded men of Charlemagne." He was a man who conquered where he stood, for there was about him such weight and power, such a dominance of personality, that others instinctively gave him the right of way. He possessed what Emerson has named character, "a reserved force which acts directly by presence and without means."

He was nobly born, for his cradle was rocked in a home where there was no confusion of material and moral values, but where



virtue was put above pleasure and service above gain. His father was a pioneer itinerant preacher who delivered his message in twenty-four appointments scattered through six states. When on April 13th, 1823, at Strafford, Vermont, a boy child came to the parsonage, the father gave him the baptismal names of George and McKendree in honor of two of the early bishops of the Methodist Episcopal church.

In that day the circuit rider's salary was a mere pittance and it was necessary for the children to be put to work. Thus George early learned the valuable lessons of labor, economy, and self denial, and was hardened for the later experiences of a strenuous life.

His education was obtained at Wesleyan University, which he entered in 1846. Stephen Olin was president, a man of imperial intellect, of magnetic eloquence and of lofty Christian character. The influence of this powerful personality upon young Steele was formative and put a high idealism back of all of his work. His college course was the product of indomitable resolution, and was begun in poverty and completed without financial assistance.

After his graduation he entered the ministry of the Methodist Episcopal church and served various charges for twelve years in the New England Conference. He soon won a reputation as a logical and scholarly preacher. It was at this time that he became a member of "The Triangle," a club celebrated in the traditions of Methodism. The other members were Fales Newhall, the critical scholar and brilliant divine, and Gilbert Haven, later a celebrated bishop of the Methodist church. These three met weekly to read Greek and Hebrew together and discuss the various problems of knowledge. This intellectual brotherhood soon became, as has been said, "A new and transforming leaven in New England Methodism and in the broader arena of New England life." Their scholarly labors soon found expression in magazine articles, pamphlets and books, and above all in broadening, uniting, and liberalizing the religious spirit of the church with which they were connected. One who was close to him in these days of intellectual acquisition and quickening says, "Probably, where a clear judgment was needed for some deep question, Steele had no superior in the Triangle, even if he had a peer."

In 1865 he was called to the presidency of Lawrence Univer-

sity, where he labored for fourteen years. During this time he became an active member of this association. The institution, when he became president, demanded a man of great resources, for he had to act as financial agent, administrator, and teacher. Dr. Steele bore these burdens with remarkable self sacrifice and great efficiency. He developed the finances of the institution and impressed upon it the loftiest moral and intellectual ideals. He took an active part in the public life of the commonwealth, and it is doubtful if any Wisconsin educator, during the same number of years, has exerted a more potent influence for good.

When he resigned at Lawrence, he became president of Wilberham Academy, one of the most historic seminaries of the country. Here he became a veritable Arnold of Rugby in his sympathy with growing life and his ability to inspire and direct it. After thirteen years of service in this institution, he resigned to spend the evening of his life in less arduous labors. He took up his residence at Auburndale, Massachusetts, where he was again pressed into service and for five years acted as vice-president and professor of philosophy at La Salle Seminary. Here disease laid its heavy hand upon him and having lost his wife, whom he loved as few men know how to love, he moved to Chicago to spend his remaining days in the home of his only son, who did all that affection and wealth could do to bless his failing years. The last few months of his life were spent in severest suffering, but the gladness and vigor of his imperial spirit rose above the pains of the flesh and made him an example and a blessing to all who came within the sphere of his influence. At last the end came quietly and his visions of faith became realities.

"Dead he lay among his books
The peace of God in all his looks."

In concluding this sketch I wish to say a few words about Dr. Steele as a teacher, an author, and a man. Dr. Charles Little has said the intellectual problem of every age is not to found schools, but to find the school master. Dr. Steele was a great school master. To establish this I wish to quote testimony from two of his pupils. Dr. Olin A. Curtis, professor of Systematic Theology in Drew Theological Seminary, himself one of the most brilliant scholars and inspiring teachers in our country, speaks as follows: "In twelve years of stu-

dent life in four countries, I had twenty-eight teachers, but I have not the least hesitation in saying that George M. Steele was the greatest teacher of them all. He was not remarkable as a scholar, nor as a pedagogical tactician, nor as an enthusiastic specialist, lifting one study into fascinating dignity, but, precisely like Thomas Arnold, he could create for a student a new world. This he did by a peculiar combination in method. On the one side by the most natural, penetrating, and stimulating sympathy he entered the student's person and vitalized all kinds of noble motives—in fact, made the man all over in heart. On the other side, he had an efficient way of relating scholarship to life. His class room was a place of large horizons. It was like climbing a mountain in a clear day and looking down upon your little door-yard. Coming out of a class one day a boy said, 'He makes a fellow see forty miles.' "

The second testimony is from that queenly and cultured woman, Margaret J. Evans of Carleton College, who graduated under him and taught with him for four years at Lawrence. She says: "By his great personality he transformed dullards into scholars, weaklings into robust students, frivolous girls into earnest women, selfish boys into ministers and missionaries—even incipient criminals into noble citizens." Another of his pupils affirms, "his class room was one of the way stations on the pathway of truth and integrity." Unquestionably we may say that as a teacher he lives immortal in "souls made better by his presence."

As an author, considering the distracting character of his peculiar work, he rendered no inconsiderable service. The ripe fruit of his thought found its way into our foremost magazines: the Atlantic Monthly, the North American Review, the Methodist Review, and many other leading periodicals. For forty years but few weeks went by when the public was not treated to something from his busy pen. He discussed with apparent ease the most varied subjects—literary, biographical, theological, political, social, historical, and educational. Several papers written by him are printed in the Transactions of this society. His books are as follows: Outlines of Bible Study for Colleges, a volume of college sermons, Elementary Psychology, Ethics, and a work on political economy. All of his publications manifest independence of thought, logical power, and vigorous expression. He was not an accumulator

of other men's thoughts, but an original force in the Republic of Letters.

But it was as a man that Dr. Steele was greatest. Rectitude won with him a perpetual victory. "To be and not to seem" was his controlling thought. His rugged honesty hated every thing that savored of pretense or sham. He was the embodiment of moral and intellectual integrity. Gentle and kindly in disposition, he became rigid as granite when asked to compromise a principle. His moral earnestness, however, never led him to dogmatism, depreciation, or censoriousness. He was saved from these by "his uncommon common sense and his keen humor." He had a fine balance of judgment, got hold of the gist of things as by intuition, and rendered decisions from the standpoint of comprehensive consideration. His wit was an ever-flowing fountain. He had almost as much facility with stories as Lincoln. He made each day bright and sunny by the spirit with which he entered it. He was above all a man of sympathy and heart. His office door was always swinging open to those who wanted a word of encouragement and they never went away empty. Even his severity was hearted with kindness. He belonged not to that inferior rank which "vaunteth itself," but rather counted his life not dear unto himself if he could by any means render a helpful service. He attached men to him by bands of steel. His students loved and revered him. Says one of them, "Natural, simple, the great soul made one ashamed of littleness, meanness or deceit. To be even a trifle like him was the noblest longing of all our hearts as we watched 'that best portion of a good man's life, his little, nameless, unremembered acts of kindness and love.'" One who knew him well has thus summed up his character: "Largeness, courage, kindness, piety, radicalness in principles, magnanimity, tremendous moral earnestness, hostility to shams, hopefulness, good nature, tolerance, intellectual honesty, humor, unfaltering Christian faith, power to enrich other lives than his own." Dr. Steele certainly belonged to the number of the true and noble if not to the great.

SAMUEL PLANTZ.

By courtesy of Wisconsin State Historical Society.

JOHN BUTLER JOHNSON.

By the accidental death of Dean J. B. Johnson, on June 23rd, last, the University of Wisconsin, and the engineering and educational world suffered a very great loss; a loss not only of a highly efficient and active worker, but to an unusual extent of a strong personality.

John Butler Johnson was born of Quaker parentage on a farm near Marlboro, Stark county, Ohio, on June 11, 1850. For a number of years his schooling was obtained at the ordinary country school, but when he was sixteen years of age the family moved to Kokomo, Indiana, where he was able to attend Howard College. Later, he went to the Holbrook Normal School for a short time. From 1868 to 1872 he taught school in Arkansas and Indiana, and in the latter year became secretary of the Indianapolis school board. He also taught for a time in the Indianapolis high school.

In 1874 he entered the Civil Engineering course at the University of Michigan, from which he graduated in 1878 at the age of twenty-eight. During his college course he spent his vacations in work along the line of his chosen profession, both for the sake of the experience and for money to assist in paying his expenses. In carrying out this summer work he was obliged nearly every year of his course to enter school late and leave early; and yet he found time to do that which he so strongly advised all his students,—attend occasional lectures in other departments and to take part in the college activities. Doubtless his mature age and experience enabled him to profit much more by his college course than the average student, and the position he has since won has been a great encouragement to any young man who, like himself, has begun his college education somewhat late in life.

After graduating, Professor Johnson was engaged until 1881 on the survey of the Great Lakes, and from 1881 to 1883 he was assistant engineer on the Mississippi River Commission, in which position he accomplished considerable work of importance. During one of the greatest floods ever experienced on the lower Mississippi, he was commissioned to measure the discharge through various crevasses, a somewhat dangerous and dif-

ficult task. As a result of these measurements and of studies made at that time, he made several recommendations regarding the method of river control, which, although considered radical at the time, have since proved to have been wise and peculiarly foresighted.

In 1883 he became professor of Civil Engineering at Washington University, St. Louis, where he remained for sixteen years. During the years spent in this position he gained a world-wide reputation by his valuable contributions to engineering literature and by his active work in connection with engineering and scientific societies. Probably his greatest contribution to the engineering profession has been his four published works on engineering subjects, all of which he prepared while at St. Louis. The Index to Engineering Periodical Literature, which he originated and to which he gave a large amount of his time, is scarcely less important. The encouragement of this work well illustrates one of his chief aims, which was, as has been well said, "the promotion of the cause of good engineering in America." During the years from 1892 to 1895 he also carried out important investigations on the strength of timber for the Forestry Division of the U. S. Department of Agriculture, which have been of great value to builders and engineers. The results there obtained are now quoted in all handbooks of engineering data.

Professor Johnson's greatest activities were in engineering education, and his reputation as an educator was at this time so well established that when he was called to the Deanship of the College of Engineering of the University of Wisconsin, in 1899, it was confidently felt by all who knew him that the right man had been found for the place. And this feeling has been more than justified by the service he has done the College of Engineering and the University during his short administration. The large growth in the attendance in the College, the increase in equipment, and the construction of the new Engineering Building, are the more evident signs of progress which have been in great measure due to his labor. But it is not too much to say that Professor Johnson's greatest service to the University was in the influence he exerted in broadening the spirit of the Engineering College and in cultivating a healthy *esprit de corps* among the student body. His attitude towards engineering education was of the broadest, and he fre-

quently urged upon his students the desirability of utilizing every opportunity for extending their horizons while in college. He had great faith in young men and believed thoroughly in the policy of placing upon them a large measure of responsibility. His influence with his students was due in no small measure to this attitude of confidence in them, together with a readiness to aid them with words of encouragement and advice.

Professor C. M. Woodward, a colleague of Professor Johnson for many years, says of him, "As a teacher Professor Johnson was sympathetic, painstaking, progressive, and very thorough. He was never content with what he did last year. He never found it possible to repeat an old lecture. Study and experience added largely to his value, and his students are most emphatic in their praise of his influence upon their lives, both technically and morally. The 'Professor' had a wholesome disrespect for mere authority. His mind was pre-eminently free from prejudice and always rational. He was a hard worker and his students learned to work hard with him. Whether in the class room or in the field, he was indefatigable."

While, first of all, an inspiring teacher, Professor Johnson was also deeply interested in all that contributed to the welfare of society. He was a member of many engineering and other societies and in all these his activity and helpfulness were almost remarkable. In the church he was equally active and in all worthy enterprises of the community was always ready to lend a hand. He was exceedingly optimistic and his mind was full of plans and projects. While not always successful in these plans, he never had time to worry over failures; he lived in the future, never in the past. It seems most unfortunate that a man should be taken away in the prime of life with such great promise for future work; and yet it was in one sense, as he would have wished,—that as long as he lived he would be able to do with vigor his full part in society. His loss is felt by a very wide circle of friends and by many interests, but by none more keenly than his students and the younger generation of engineers to whom he was an inspiration and guide.

LIST OF IMPORTANT WRITINGS OF PROFESSOR JOHNSON.

Recently Improved Methods of Sewage Disposal, Bulletin, Eng. Series, Univ. of Wis., Vol. II, No. 7, 1900.

The Strength of a Nation,—Unity. June 16, 1900.

American Industrial Education, What Shall It Be? A Committee Report written by Professor Johnson, as chairman. Proceedings of the Society for the Promotion of Engineering Education, Vol. VIII, 1900.

Engineering Contracts and Specifications. New York, Engineering News Pub. Co.

Materials of Construction. New York, John Wiley & Sons.

Joint Author, Modern Framed Structures. John Wiley & Sons.

Theory and Practice of Surveying. John Wiley & Sons.

Editor, Index of Current Engineering Literature, Volumes I and II.

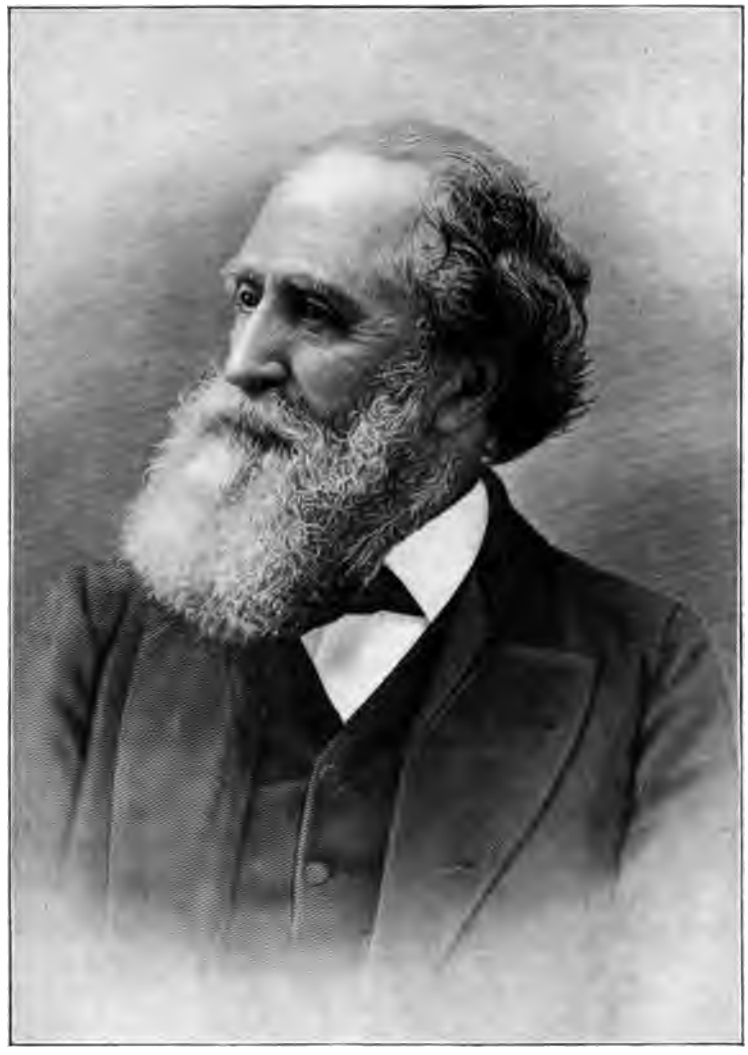
F. E. TURNEAURE.

SAMUEL DEXTER HASTINGS.

Samuel Dexter Hastings was born at Leicester, Worcester county, Massachusetts, July 24, 1816. His father, Simon Hastings, was of English blood, a lineal descendant of Thomas Hastings, who emigrated from England, in 1634, and settled in Watertown, Mass., and who long held important positions both in church and state. His mother, Betsy (McIntosh) Hastings, was of Scotch descent, the daughter of Peter McIntosh, of Boston, who served in the war of the American revolution under the command of General Washington.

The subject of this sketch spent his earlier years in Boston, and his regular school training was limited to the first thirteen years of his life. At the age of fourteen he went to Philadelphia, and made that city his home for the next sixteen years. The early part of this period was mainly devoted to a course of study in preparation for a mercantile career, and we find him actually engaged in business on his own account before he had reached the age of twenty-one.

This sojourn at Philadelphia was the formative period of young Hastings' life, but his innate sense of justice, and his



Saml. D. Hastings

deeply sympathetic nature—those qualities of head and heart which grew and strengthened with his years—were never satisfied with mere money making. In 1835, he became deeply interested in the anti-slavery movement. He was one of the founders of the "Liberty" party in Pennsylvania, and, at the age of twenty-four, was made chairman of its state central committee. Through his zeal and activity in this movement he became intimately associated with such men as James G. Birney, William Lloyd Garrison, John G. Whittier, Gerritt Smith, Wendell Phillips, and with many others of national fame. His attitude, at so early an age, toward slavery, and his activity in this organized movement against it, was but a single illustration of his inborn hatred of oppression, and of his sympathy with the unfortunate everywhere, as shown in so many ways throughout his entire life.

In 1846, Mr. Hastings removed to Wisconsin Territory and settled in Walworth county. He at once became identified as an active citizen with the public interests of the territory, and soon after, with those of the state. He was immediately placed in positions of public trust, and yet never through his own seeking. He was called to act as town clerk, justice of the peace, chairman of his town and county boards, and was elected to the legislature of 1849, and sat as a member of that body at its first winter session after the territory became a state. He was regarded as one of the able members of the assembly, and was held in high esteem by his associates. The excitement over the subject of slavery and its extension into the territories was then running high, and Mr. Hastings' speech, made before the assembly in support of certain resolutions upon this subject, was widely circulated by the newspaper press, and was afterwards republished and further circulated as one of the documents of the Anti-Slavery Society. These resolutions, of which Mr. Hastings was the author, were, with slight alterations, passed by the two houses, and thus committed the state, for the time being at least, to the views therein contained.

In 1852, Mr. Hastings removed to the city of La Crosse, but soon after took up his residence in the village of Trempealeau, near by, where he had already acquired property. Here he was again called into political life. He was chosen a member of the assembly in 1856, and in the year following was nominated and elected treasurer of the state. This responsible office

he held during four successive terms of two years each, thus outranking any other treasurer of the state in length of service, and perhaps equaling any in the efficiency of the service. This period, too, extended over those trying years of the civil war when the resources of the state were taxed, in every sense, to their utmost.

But Mr. Hastings was never ambitious for political preferment. He was a true lover of mankind, and, as such, he stood ready to enlist in every movement which he believed was calculated to serve humanity. He was a leading spirit in the organization of the national board of charities and reform, and also of the Wisconsin state board of charities of which he was for several years the efficient secretary.

But it is, perhaps, in connection with temperance reform that Mr. Hastings' name is most closely associated and most widely known. He enlisted early in this cause, and never for a moment permitted his zeal to flag or his courage to falter. He became identified with all the great temperance organizations, national and international. He assisted in organizing the "National Temperance Society and Publication House," with headquarters at New York City, and served as its vice-president from the inception of the organization until his death. He was a member of the national order of the "Sons of Temperance," and was for several years the chief officer of the Wisconsin branch of that body. He was also a member of the "Independent Order of Good Templars," and for six years he held the highest office in the gift of this international organization.

In the interest of these orders, and of the general cause of temperance, he lectured through every county of Wisconsin, in nearly every state of the Union, and also in Canada, England, Scotland and Ireland. In this work of lecturing and organizing he crossed the Atlantic six times, made two trips around the world, and spent sixteen months in Australia, New Zealand and Tasmania. He assisted in organizing the "Prohibition" party, and was a member and the treasurer of its national executive committee for twenty years. He was also his party's candidate in Wisconsin for member of congress, in 1882, and for governor of the state in 1884.

It is hardly necessary to add, what is clearly implied in the sketch already given, that Mr. Hastings was, throughout his life, an earnest christian. It was the very catholic spirit of his

religion which led him to join in every movement which he believed was calculated to benefit mankind and help "lead in the kingdom of righteousness."

He united, at an early age, with the Presbyterian church, but his unyielding attitude upon the slavery question soon led to a severance of this relationship. He then became a member of the Congregational church, and maintained his connection with that organization through the remainder of his life. He entered into all of its activities, religious, charitable and educational, with his characteristic zeal. He believed his church was organized to work as well as to worship, or rather, to worship through work—that its mission was to help uplift humanity, and that whatever tended to that end—whatever made men healthier, happier and better—was legitimate christian work. A man with such views cannot well be a laggard. His place is at the front. Mr. Hastings was always a leader in his church, and, as a result, he was honored with every position of trust and confidence to which a lay member is eligible.

He was a firm believer in the Chautauqua method of reaching and educating the public, and was active in helping to organize and maintain the "Monona Lake Sunday School Assembly." He served, at different times, as its secretary and treasurer, and, at the time of his death, held the office of president. The work of this Assembly lay near to his heart. He entered into it with an enthusiasm born of faith in the good ends he believed it would subserve. These restful mid-summer meetings were well suited to the afternoon of his long and active life. His presence upon the grounds was always a sort of benediction, and no other face there was quite so familiar as his.

Mr. Hastings was not an educated man in the ordinary sense, but was a diligent student of men and things, and a true friend of liberal culture. He was willing to serve wherever his service was most effective. He made no claim of proficiency in the sciences, or in arts or letters, yet he was a charter member of this Academy, and, for nearly twenty years, was its faithful and efficient treasurer. He gave much time to the study of sociological problems, and sought to interest others in their solution—in fact, his whole life illustrates the value of industry and perseverance stimulated by a high moral purpose. The principles he advocated were exemplified in his own walk and character. He was no pessimist; he believed the world was grow-

ing better, but, too slowly. As a true reformer, he was always buffeted, often disappointed, but never disheartened. He hated slavery and was a foe to intemperance, and in waging war against them he was impatient of compromise. Honest men may have differed with him at times as to the means of reaching the end desired, but no breath of suspicion ever rested upon his honesty of motive or integrity of purpose. He tried to make the world a little better than he found it, and it succeeded. His was the life of an earnest, active, christian citizen—well-rounded and symmetrical,—and this is the richest legacy he could have left to his family, or to the world.

J. B. PARKINSON.

HAMILTON GREENWOOD TIMBERLAKE.

Mr. Hamilton Greenwood Timberlake was born Dec. 8, 1871, at Medley Springs, Berkeley county, West Virginia. In 1884 his widowed mother removed with her family to Port Byron, Ill., and it was there that Mr. Timberlake received his early education and preparation for college.

He was a quiet boy, much over his books, and in the Port Byron Academy his studies were mainly in Greek and Latin and mathematics, perhaps because there was little opportunity for work in scientific lines and the animus of the school was strongly in favor of the then so-called regular college preparatory course, which was framed to meet the requirements of the classical course in the denominational colleges. His determination at that time was to take a college and seminary course preparatory to entering the ministry. From the start he was largely dependent on his own resources, and after graduating from the academy he taught for a year in the district schools and a second year as principal in the town of New Bedford, Ill.

In the fall of 1893 he entered the classical course in Lake Forest University. Under the influence of the then new president of Lake Forest, Dr. John M. Coulter, and in the atmosphere of transition from a rigid course system to that of freer electives which was brought in with the new administration, Mr. Timberlake's interests gradually changed and while continuing his studies in the classics, he devoted more time to the

By courtesy of Wisconsin Alumni Magazine.

sciences and came to the determination to pursue more advanced studies in Botany after graduation.

In college, though he impressed his fellow students as rather reserved, he still found himself drawn into taking an active part in many of the lines of student activity outside of the class room. He was prominent in the work of the literary societies, and during his senior year was editor of the college paper.

After graduating from Lake Forest with the degree of A. B. in 1897, he spent two years in graduate work in Botany in the University of Michigan, holding first the position of assistant, and later that of instructor in Botany.

In 1899 he took his Master's degree, presenting a thesis on a subject in the line of the cell studies, to which he had determined to devote himself. In the same year he was made instructor in Botany in the University of Wisconsin and in 1903 was promoted to an assistant professorship. On June 30 of this same year he was married to Miss Violet Slack of Madison. He had also received an appointment as a research assistant under the Carnegie Institution and was granted leave of absence by the University for a year to devote himself to research under the Carnegie appointment.

His death, July 19, 1903, resulted from a fall due, possibly in part, to a recurrence of an inherited heart trouble from which he had suffered as a child, but from which he had apparently entirely recovered in later years.

On coming to Madison Mr. Timberlake devoted himself to the study of the cytology of the algae, for which the region offers especial advantages, and in the few short years of his work here he had already attained results which are of permanent and fundamental value to botanical science. His work on the processes of starch formation not only gives us for the first time an account of the remarkable processes which go on in the starch-forming centers in the alga cell, but opens up the whole field of the study of metabolism by a new method and from a new standpoint.

It is, of course, especially difficult to judge of scientific work, so much of which was incomplete and in the making, but it is not too much to say that Mr. Timberlake's work had already given evidence that he possessed to an unusual degree the quality of genuine critical insight which discerns the real problems, the crucial points, for whose solution scientific progress

in any particular line waits, and that his interest centered in such fundamental work. He was a keen observer, but fragmentary observations of merely curious or unrelated details won little attention or interest from him. Chance discoveries of this sort in his field and experimental work served only as point of remarks or discussion in class or with his friends. He was singularly free from that tendency to publish as a form of advertising which leads to the deluge of fragmentary undigested work with which our minor scientific journals are sometimes loaded.

Mr. Timberlake had very little of that zeal for collecting and accumulating herbarium specimens which has been at least the starting point in the work of many botanists. He was an enthusiastic student of plant life in the fields, but his search was always for special material which should serve in the solution of some one of the biological problems with which his mind was full. In his chosen field of work on the algae, he has enlarged our knowledge of the local flora by the discovery of some of the most interesting and important forms for physiological study and he had accumulated a very large amount of carefully preserved material for his further researches. The most characteristic feature in his method of work was perhaps his tireless patience and persistency and an unusual capacity for taking pains in all the details of his experimental work.

As a teacher, Mr. Timberlake won the love and respect of all who knew him, both at Ann Arbor and in Madison. Though quiet and unostentatious he none the less impressed his methods and standpoints both on his pupils and associates to an unusual degree. He was especially successful in giving the sort of personal help and inspiration which counts for more than the mere formal work of the class room, and his clearness in explanation and force in impressing the essential points on his students in the laboratory, were his most marked characteristics as a teacher.

Personally Mr. Timberlake endeared himself to all who came to know him well. His evenness of disposition and unfailing good humor, together with an ever-ready but unostentatious helpfulness, made him friends everywhere. Those who knew him best and longest learned to rely most fully on his thorough sincerity. The circle of his most intimate friends mourn his death as an irreparable personal loss.

The following is a list of the titles of his published papers. A very large amount of work was left in an unfinished condition, and it is hoped that of this at least the portions relating to his further studies on starch formation in the algae, for which the drawings were largely completed, may be prepared for publication.

"The Development and Function of the Cell-Plate in Higher Plants."—The Botanical Gazette, Vol. XXX, p. 73, 1900.

"Swarmspore Formation in Hydrodictyon Utriculatum Roth."—The Botanical Gazette, March, 1901.

"Starch Formation in Hydrodictyon Utriculatum."—Annals of Botany, Vol. XV, p. 619, 1901.

"Starch Formation in Cladophora."—Science, March 21, 1902.

"Cell Division in Riccia Fluitans."—Science, March 21, 1902.

"Development and Structure of the Swarmspores of Hydrodictyon."—Trans. Wis. Acad. of Sci., Arts, and Letters, Vol. XIII, p. 486, 1902.

"The Nature and Function of the Pyrenoid."—Science, March 20, 1903.

R. A. HARPER.

FREDERICK PABST.

Frederick Pabst, the son of Gottlieb and Frederika Pabst, was born in Thuringen in Saxony, Germany, March 28, 1836, and died at his home at 2000 Grand Ave., Milwaukee, on New Year's day, 1904. With his father and mother he came to Milwaukee in 1848, and a few months later accompanied them to Chicago, where the mother died in 1849. About this time the father accepted a position as cook in a Chicago hotel and Frederick waited on the table for five dollars a month. Soon after he obtained a similar position in another hotel, and about the year 1850 went aboard one of the Goodrich steamers, plying upon Lake Michigan, as cabin boy. From this humble position he rose rapidly, and at the age of twenty-one he was made captain of the steamer Huron.

In 1862 Captain Pabst was married to Marie, the daughter of Philip Best, son of the founder of the brewing firm of Jacob

Best & Sons. His marriage into the Best family proved to be the turning point in his career, for the ties of home and family soon became stronger than his liking for the life of a lake captain, and he transferred all his interests to the brewing business of Philip Best who had become the owner of the brewery founded by his father.

With the same energy and ability that had brought about his rapid rise in the steamboat business, Captain Pabst set about learning the brewing business, beginning at the bottom and mastering every detail. He introduced new methods and new machinery and greatly increased the output while reducing the cost of manufacture. Under his direction the business of the company increased enormously and in 1889 the name was changed from the Philip Best Brewing Company to the Pabst Brewing Company. Captain Pabst's great business ability was shown not less in the conduct of the mammoth establishment in Milwaukee than in the extension of its trade to all parts of the United States and even to foreign countries. At the time of his death the Pabst Brewing Company was the largest concern of the kind in the world.

Captain Pabst was admired by all who knew him as a man of sterling honesty and fine public spirit. He was chiefly instrumental in the building of the Stadt theater, the predecessor of present Pabst theater, one of the best appointed theaters in the country, devoted to the cultivation of the German drama. His private charities are said to have been large and to have been bestowed with care and discrimination. He was a member of many fraternal, social and business organizations. Among these are the Milwaukee Musical Society, Aurora Lodge, No. 30, Free and Accepted Masons, Ivanhoe Commandery, No. 24, Knights Templar. He became a member of the Wisconsin Academy of Sciences, Arts, and Letters at the annual meeting December, 1896.

COMPILED BY THE SECRETARY.

JOHN I. JEGI.

John I. Jegi was born in Buffalo county, Wisconsin, on December 3rd, 1866. His education was begun in the district schools of his native county. Later on he attended the high school at Arcadia, where he prepared himself to teach in the public schools. He began his career as a teacher at Courtland, Wisconsin in 1882. From this place he went to Arcadia and then to Osseo, at which place he remained until 1888. During the years 1888–1889 he was a student at the Northern Illinois Normal School at Dixon. For two years he was principal at Blair, Wisconsin, and this was followed by a three year term in the same capacity at Arcadia where he had previously taught. Leaving Arcadia in the summer of 1894, he entered the University of Chicago, which institution conferred upon him the degree of Bachelor of Science in 1896. In the same year he was called to the chair of Psychology and Physiology in the State Normal School at Milwaukee, which position he filled acceptably until the time of his death, which occurred on January 7, 1904. The degree of Master of Science was conferred upon him by the Northern Illinois Normal School in 1898.

Professor Jegi was elected to membership in the Wisconsin Academy of Sciences, Arts, and Letters in December, 1896. From the beginning he took an active interest in the work of the Academy. In 1901 he was made a member of the Library committee, and in 1902 was elected one of the vice-presidents to serve for three years. He did much to arouse interest in the work of the Academy among the citizens of Milwaukee, and almost the last work that he was able to do was to assist in perfecting arrangements for the December meeting in 1903.

Professor Jegi's published papers are as follows:

A Comparative Study of Auditory and Visual Memory. Contributions to Philosophy—University of Chicago Press.

Children's Ambitions. Illinois Society for Child-Study. October, 1898.

A Two-Year-Old Child's Vocabulary. Child Study Monthly.

Auditory Memory-Span for Numbers in School Children. Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, 1904.

Besides his published papers he has written a considerable number of short papers, most of which have been read before various educational and scientific associations.

He has also published two text books in physiology. These are:

A Syllabus of Human Physiology. S. Y. Gillan & Co., Milwaukee, 1901.

Practical Lessons in Human Physiology. The MacMillan Co., New York, 1903.

I. W. MITCHELL.

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†Deceased, January, 1904.

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M. D. (Harvard). Physician.

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DAVIS, John Jefferson, 504 Monument Sq., Racine.

B. S. (Illinois); M. D. (Hahnemann). Physician.

DENSMORE, Hiram Delos, 718 Clary St., Beloit.

A. B., A. M. (Beloit). Professor of Botany, Beloit College.

DERNEHL, Paul Herman, 942 Second St., Milwaukee.

B. S. (Wisconsin). Student, Johns Hopkins University Medical School.

DESMOND, Humphrey J., 395 E. Water St., Milwaukee.

B. L. (Wisconsin); A. M. (Notre Dame). Lawyer.

DIETRICH, Otto, St. James Court, 85 Grand Av., Milwaukee.

Ph. D. (Halle). Director, Milwaukee University School.

DOWLING, Linnaeus Wayland, University Heights, Madison.

Ph. D. (Clark). Assistant Professor of Mathematics, University of Wisconsin.

DOWNES, Robert Hugh, 53 W. Algoma St., Oshkosh.

B. L. (Wisconsin).

DUDLEY, William H., Platteville.

Instructor in Biology, State Normal School.

EATON, Edward Dwight, 847 College Av., Beloit.

A. B., A. M. (Beloit); B. D. (Yale); LL. D. (Wisconsin); D. D. (Northwestern, Yale). President and Professor of Ethics, Beloit College.

ELY, Richard Theodore, University Heights, Madison.

A. B., A. M. (Columbia); Ph. D. (Heidelberg); LL. D. (Hobart). Professor of Political Economy, University of Wisconsin.

ERICKSON, Frank Morton, Ripon.

A. M. (Wabash). Professor of Greek, Ripon College.

EWING, Addison Luther, River Falls.

B. S., M. S. (Cornell). Professor of Natural Science, State Normal School.

FARLEY, Herbert John, Appleton.

M. S. (Lawrence). Instructor in Philosophy, Lawrence University.

FERRY, George Bowman, 19 Woodland Court, Milwaukee.

Architect (Ferry and Clas).

FISCHER, Richard, Madison.

Ph. C., B. S. (Michigan); Ph. D. (Marburg). Assistant Professor of the Theory and Practice of Pharmacy, University of Wisconsin; State Chemist, Wisconsin.

FOLKMAR, Daniel, Bontoc, P. I.

A. B., A. M. (Western); S. D. (Brussels); D. O. (Paris). Lieutenant Governor, Leponto, Bontoc, P. I.

FRANKENBURGER, David Bower, 115 W. Gilman St., Madison.

Ph. B., LL. B., A. M. (Wisconsin). Professor of Rhetoric and Oratory, University of Wisconsin.

FROST, William Dodge, 310 Bruen St., Madison.

B. S., M. S. (Minnesota); Ph. D. (Wisconsin). Assistant Professor of Bacteriology, University of Wisconsin.

GAPEN, Clarke, Madison.

M. D. (.....). Physician.

GIESE, William Frederick, 426 Bruen St., Madison.

A. B., A. M. (Harvard). Associate Professor of Romance Languages, University of Wisconsin.

GORDON, Mrs. George, 1144 Humboldt Av., Milwaukee.

GRAENICHER, Sigmund, 551 Seventh St., Milwaukee.

Ph. D. (Basel); M. D. (Munich). Physician.

GREGORY, John Goadby, 717 Jefferson St., Milwaukee.

Associate Editor, The Evening Wisconsin.

HAESSLER, Luise, 474 Walker St., Milwaukee.

Teacher of Modern Languages and Librarian, South Division High School.

HALSEY, Rufus H., Oshkosh.

A. B. (Williams). President, State Normal School.

HANCOCK, Edward Lee, La Fayette, Ind.

B. S., M. S. (Wisconsin). Instructor in Applied Mechanics, Purdue University.

HARPER, Robert Almer, 324 N. Carroll St., Madison.

Ph. D. (Bonn). Professor of Botany, University of Wisconsin.

HARVEY, Nathan Albert, 613 W. 67th St., Chicago.

Ph. D. Vice-Principal, Chicago Normal School.

HARWOOD, Mary Corinthia, Ripon.

B. L., M. L. (Lawrence). Professor of French and German, and Dean of Women, Ripon College.

HENRY, William Arnon, University Farm, Madison.

B. Agr. (Cornell). Dean of the College of Agriculture and Director of the Agricultural Experiment Station, University of Wisconsin.

HILLYER, Homer Winthrop, University Heights, Madison.

B. S. (Wisconsin); Ph. D. (Johns Hopkins). Assistant Professor of Organic Chemistry, University of Wisconsin.

HODGE, Willard Addison, Madison.

A. B., A. M. (Ripon).

HOHLFELD, Alexander Rudolph, 145 W. Gilman St., Madison.

Ph. D. (Leipzig). Professor of German, University of Wisconsin; member of the Executive Council and Chairman of Central Division, Modern Language Association of America.

HOLLISTER, Albert Henry, 17 Langdon St., Madison.

Pharmacist.

HOOK, Edward Alfred, Columbia University, New York, N. Y.

B. S., M. S. (Wisconsin). Tutor in Mathematics, Columbia University.

HUBBARD, Frank Gaylord, 227 Langdon St., Madison.

A. B. (Williams); Ph. D. (Johns Hopkins). Professor of the English Language, University of Wisconsin.

HUNTINGTON, Ellsworth, Milton, Mass.

A. B. (Beloit); A. M. (Harvard). Geologist, Geological Exploration Expedition in Central and Southern Asia Under Carnegie Institution.

JASTROW, Joseph, 247 Langdon St., Madison.

A. B., A. M. (Pennsylvania); Ph. D. (Johns Hopkins). Professor of Psychology, University of Wisconsin.

JENNINGS, John Thompson Wilson, Univ. Heights, Madison.

B. S. (Cornell). Superintending Architect of Buildings and Grounds, University of Wisconsin.

JOHNSON, Roswell Hill,

B. S. (Chicago).

JOHNSON, Warren Seymour, Milwaukee Club, Milwaukee.

Mechanical Engineer.

JOLLIFFE, William Morley, 604 Elmore St., Escanaba, Mich.

B. S. (Lawrence). Superintendent, Public Schools.

JUDAY, Chancey, 1060 Twelfth St., Boulder, Colo.

M. A. (Indiana). Assistant, Wisconsin Geological and Natural History Survey.

KAHLENBERG, Louis, 234 Lathrop St., Madison.

B. S., M. S. (Wisconsin); Ph. D. (Leipzig). Professor of Physical Chemistry, University of Wisconsin.

KIMBALL, Mather Dean, 528 Frederick St., Milwaukee.

A. B., A. M. (Northwestern).

KING, Franklin Hiram, 1540 University Av., Madison.

Chief of Division of Soil Management, Bureau of Soils, U. S. Department Agriculture.

KLING, Henry F., 33rd St. and Wentworth Av., Chicago, Ill.

Ph. B., A. M. (Upper Iowa). Principal, Webster School, Chicago.

KNOWLTON, Amos Arnold, University Heights, Madison.

A. B., A. M. (Bowdoin).

KREMERS, Edward, 320 Jackson St., Wingra Park, Madison.

Ph. G., B. S. (Wisconsin); Ph. D. (Göttingen). Professor of Pharmaceutical Chemistry, University of Wisconsin.

KRUEGER, Henry, 385 Twenty-seventh Av., Milwaukee.

Principal, Twelfth District School, No. 1.

KUHN, Harry, Toledo, Ohio.

Clerk, with Franc, Heyn and Company.

LAIRD, Arthur Gordon, 619 Langdon St., Madison.

Ph. D. (Cornell). Assistant Professor of Ancient Languages, University of Wisconsin.

LAMB, Francis Jones, 212 N. Carroll St., Madison.

LEAVENWORTH, William Stowell, Olivet, Mich.

M. Sc. (Hamilton). Professor of Chemistry, Olivet College.

LEGLER, Henry E., Madison.

Secretary, Free Library Commission.

LEHMANN, Harriet, 1906 Sherman Av., Evanston, Ill.

A. B. (Ripon). Graduate Student, Northwestern University.

LENHER, Victor, 148 W. Gorham St., Madison.

Ph. D. (Pennsylvania). Associate Professor of General and Theoretical Chemistry, University of Wisconsin.

LEITH, Charles Kenneth, 240 Langdon St., Madison.

B. S., Ph. D. (Wisconsin). Professor of Economic and Structural Geology, University of Wisconsin; Assistant Geologist, United States Geological Survey.

LIBBY, Orin Grant, University, N. D.

B. L., M. L., Ph. D. (Wisconsin). Assistant Professor of History, University of North Dakota.

LLOYD-JONES, Thomas R., Menomonie.

B. S. (Wisconsin). Principal, Menomonie High School.

LUEDERS, Herman Frederick, Sauk City.

B. S. (Wisconsin).

MAGNUSSON, Carl Edward, Albuquerque, New Mexico.

B. E. E., M. S. (Minnesota); Ph. D. (Wisconsin). Professor of Mathematics and Physics, University of New Mexico.

MARKS, Solon, 6 Prospect Av., Milwaukee.

M. D. (Rush). Professor of Fractures and Dislocations and Military Surgery, Wisconsin College of Physicians and Surgeons.

MARSHALL, Ruth, Appleton.

M. S. (Wisconsin). Teacher, Ryan High School.

MARSHALL, William Stanley, 116 E. Gorham St., Madison.

B. S. (Swarthmore); Ph. D. (Leipzig). Assistant Professor of Zoölogy, University of Wisconsin.

MAURER, Edward Rose, University Heights, Madison.

B. C. E. (Wisconsin). Professor of Mechanics, University of Wisconsin.

McKENNA, Maurice, 78 Third St., Fond du Lac.

Attorney at Law; President of the Bar Association of Fond du Lac County.

McMINN, Amelia, 172 Twenty-first St., Milwaukee.

B. S. (Wisconsin). Instructor in Biology, West Side High School.

MEACHEM, John Goldsborough, Jr., 745 College Av., Racine.

M. D. (Rush). Physician.

MERRILL, Harriet Bell,
Milwaukee Public Museum, Milwaukee.

B. S., M. S. (Wisconsin). Lecturer to Schools.

MERRILL, J. A., State Normal School, West Superior.

B. S. (Harvard). Director of Science Courses, State Normal School.

MERRILL, Mrs. Sherburne S., 3355 Grand Av., Milwaukee.

First Vice-President, Wisconsin Humane Society; Second Vice-President Woman's Club of Wisconsin; President, Public School Art League.

MEYER, Balthasar Henry, University Heights, Madison.

B. L., Ph. D. (Wisconsin). Professor of Institutes of Commerce, University of Wisconsin; Member State Board of Examiners.

MILLER, William Snow, 422 N. Henry St., Madison.

M. D. (Yale). Associate Professor of Vertebrate Anatomy, University of Wisconsin.

MITCHELL, Irving N., 2921 Cedar St., Milwaukee.

Ph. B. (Michigan). Professor of Biology, State Normal School.

MONROE, C. E., Milwaukee.

MORRIS, William Augustus Pringle,
1 Howard Place, Madison.
A. B. (Hamilton). Attorney at Law.

NADER, John, 302 W. Main St., Madison.
Architect and Civil Engineer.

NEHRLING, Henry, Palm Cottage Experiment Garden,
Gotha, Orange County, Fla.

NEILSON, Walter Hopper, 114 Garfield Av., Milwaukee.
M. D. (Rush). Dean of the Medical Faculty and Professor of the Principles and Practice of Medicine and Clinical Medicine, Milwaukee Medical College.

NICHOLSON, Dexter Putnam, 504 John St., Appleton.
B. S., M. S. (Lawrence). Professor of Geology, Lawrence University.

NORTON, Richard Greenleaf, 117 W. Mifflin St., Madison.
Mechanician.

NOYES, George Henry, 204 Prospect Av., Milwaukee.
A. B., LL. B., LL. D. (Wisconsin). Attorney; Ex-Judge, Superior Court.

O'SHEA, M. Vincent, 140 Langdon St., Madison.
B. L. (Cornell). Professor of the Science and Art of Education, University of Wisconsin.

OWEN, Edward Thomas, 614 State St., Madison.
A. B., Ph. D. (Yale). Professor of the French Language and Literature, University of Wisconsin.

PALMER, Bernard Morey, Janesville.
B. L. (Wisconsin). Attorney at Law.

PARKER, Fletcher Andrew, 14 W. Gilman St., Madison.
Professor of Music and Director of School of Music, University of Wisconsin; Vice-President, Music Teachers' National Association.

PARKINSON, John Barber, 803 State St., Madison.
A. B., A. M. (Wisconsin). Vice-President and Professor of Constitutional and International Law, University of Wisconsin.

PAULY, Hugo Albert, 536 29th St., Milwaukee.
B. S. (Wisconsin).

PEPPELL, S. V., 431 W. Main St., Louisville, Kentucky.
Proprietor, U. S. Bureau of Consulting Chemists and Engineers.

PERELES, James M., 529 Astor St., Milwaukee.
LL. B. Lawyer. Ex-President, Public School Board; President, Public Library; ex-County Judge, Milwaukee Co.; Regent, University of Wisconsin.

PERELES, Jennie W. (Mrs. J. M.), 529 Astor St., Milwaukee.
Secretary, Milwaukee Flower Mission and Mission Kindergarten.

PERELES, Nellie W. (Mrs. T. J.), 535 Astor St. Milwaukee.

PERELES, Thomas Jefferson, 535 Astor St., Milwaukee.
LL. B. (Wisconsin). Attorney at Law (Nath. Pereles and Sons); President, Milwaukee Bar Association.

PERISHO, Ellwood Chappelle, Vermilion, S. D.
B. S., M. S. (Earlham); M. S. (Chicago). Professor of Geology, University of South Dakota; State Geologist, South Dakota.

PLANTZ, Samuel, 545 Union St., Appleton.
A. M. (Lawrence); Ph. D. (Boston); D. D. (Albion). President, Lawrence University.

PORTER, William, 735 College St., Beloit.
A. B., A. M., D. D. (Williams). Professor of Latin, Beloit College.

POST, Harriet L., 1182 Humboldt Av., Milwaukee.
M. D. (Woman's Medical College of New York Infirmary). Instructor in Biology, East Side High School.

PRETTS, William Walter, 620 Tower Av., Superior.
B. S. (Wisconsin); M. D. (Northwestern). Physician and Surgeon.

PRINGLE, Ralph W., Appleton.
A. B. (Harvard); M. S. (St. Lawrence). Principal, Ryan High School; Supervisor, Second District.

PULS, Arthur John, Wells Bldg., Milwaukee.
B. L. (Wisconsin); M. D. (Heidelberg). Physician; Regent, University of Wisconsin.

PUTNEY, Frank Howell, 215 Wisconsin Av., Waukesha.

Attorney at Law. President, Waukesha Malleable Iron Company; President, Waukesha Gas and Electric Company; Vice-President, Waukesha National Bank.

RANKIN, Walter L., 201 East Av., Waukesha.

A. M., Ph. D. (Princeton). Vice-President and Professor of Latin, Carroll College.

REGAN, Katherine Patricia, 123 N. Butler St., Madison.

B. L. (Wisconsin). Assistant Principal, Jefferson High School.

REUL, Miss Matilda E., 138 First St., Baraboo.

B. S., M. S. (Wisconsin).

RICE, Ole S., Deerfield.

B. S. (Wisconsin). Principal, Deerfield High School.

RICHTER, Arthur William, 929 University Av., Madison.

B. M. E., M. E. (Wisconsin); M. M. E. (Cornell). Professor of Experimental Engineering, University of Wisconsin.

ROHDE, Hugo W., 635 Second St., Milwaukee.

B. S. (Wisconsin). Chemist, with Industrial Chemical Institute.

ROESSLER, John Samuel, 316 Arlington St., Waukesha.

B. L. (Wisconsin). Principal, State Industrial School for Boys.

ROGERS, Augustus J., 318 Ogden Av., Milwaukee.

Ph. B. (Cornell). Principal, South Division High School.

RUENZEL, Henry Gottlieb, 753 Third St., Milwaukee.

Ph. G. (Wisconsin). Pharmacist; Member, State Board of Pharmacy.

RUSSELL, Harry Luman, 1532 Univ. Av., Madison.

B. S., M. S. (Wisconsin); Ph. D. (Johns Hopkins). Professor of Bacteriology, University of Wisconsin; Director, State Hygienic Laboratory.

SALMON, Edward Payson, 618 Church St., Beloit.

A. M. (Beloit). Congregational Minister; Second Vice-President of Board of Trustees, Beloit College.

SANBORN, John Bell, Madison.

B. L., M. L., Ph. D. (Wisconsin). Lawyer.

SANFORD, Albert Hart, 1052 Clark St., Stevens Point.

B. L. (Wisconsin); A. B. (Harvard). Instructor in History and Civics, State Normal School.

SCHLUNDT, Herman, Columbia, Mo.

B. S., M. S., Ph. D. (Wisconsin). Instructor in Physical Chemistry, University of Missouri.

SCOTT, William Amasa, 520 N. Pinckney St., Madison.

A. B., A. M., (Rochester); Ph. D. (Johns Hopkins). Director of the Course in Commerce and Professor of Economic History and Theory, University of Wisconsin.

SCOTT, Winfield G., 1109 Park Av., Racine.

Director, Private Testing Laboratory.

SESSINGHAUS, Gustavus, 1360 Columbine St., Denver, Colo.

E. M. (Columbia); M. S. (Wisconsin).

SHEARIN, Hubert Gilson, Ripon.

A. B. (Central); Ph. D. (Yale). Professor of English, Ripon College.

SHERMAN, Lewis, 448 Jackson St., Milwaukee.

B. S., A. M. (Union); M. D. (New York).

SIEKER, William Christian, 251 Seventeenth St., Milwaukee.

B. S. (Wisconsin).

SKINNER, Ernest Brown, 414 Charter St., Madison.

A. B. (Ohio); Ph. D. (Chicago). Assistant Professor of Mathematics, University of Wisconsin.

SLAUGHTER, Moses Stephen, 633 Francis St., Madison.

A. B., A. M. (De Pauw); Ph. D. (Johns Hopkins). Professor of Latin, University of Wisconsin.

SMITH, Erastus Gilbert, 649 Harrison Av., Beloit.

A. B., A. M. (Amherst); A. M., Ph. D. (Göttingen). Professor of Chemistry, Beloit College.

SMITH, Howard Leslie, 222 Langdon St., Madison.

A. B., LL. B. (Wisconsin). Professor of Law, University of Wisconsin.

SMITH, Leonard Sewell, 939 University Av., Madison.

B. C. E., C. E. (Wisconsin). Assistant Professor of Topographic and Geodetic Engineering, University of Wisconsin; Engineer State Levee Commission; in charge of Hydrography, Wisconsin Geological and Natural History Survey; Hydrographer, U. S. Geological Survey.

SMITH, Walter McMynn, 218 Park St., Madison.

A. B. (Wisconsin). Librarian, University of Wisconsin.

SNOW, Benjamin Warner, 518 Wisconsin Ave., Madison.

Ph. D. (Berlin). Professor of Physics, University of Wisconsin.

SPARLING, Samuel Edward, 505 N. Carroll St., Madison.

A. B. (Indiana); Ph. D. (Wisconsin). Assistant Professor of Political Science, University of Wisconsin; Member, National Municipal League; Member of Committee on Administration, American Political Science Association; Editor, The Municipality. Secretary, League of Wisconsin Municipalities; Member of Common Council, Madison.

STARR, William J., 135 Marston Av., Eau Claire.

LL. B. (Columbia). Member, Board of Commissioners of Fisheries, Wisconsin; President of the Eau Claire Public Library.

SUYDAM, Vernon Andrew, Ripon.

B. S. (Wisconsin). Supervising Principal, Ripon High School.

TALBERT, G. A., 1060 Main St., Stevens Point.

B. S., M. S. (Ohio Wesleyan). Instructor in Biology, State Normal School.

TAWNEY, Guy Allan, Beloit.

A. B., A. M. (Princeton); Ph. D. (Leipzig). Squier Professor of Mental Science and Philosophy, Beloit College.

TELLER, Edgar E., 170 Twenty-ninth St., Milwaukee.

President, Wisconsin Natural History Society.

THWAITES, Reuben Gold, 260 Langdon St., Madison.

LL. D. (Wisconsin). Secretary and Superintendent, State Historical Society of Wisconsin; Chairman, Wisconsin Free Library Commission.

TIBBALS, Charles A., Jr., 604 Francis St., Madison.

Assistant in Chemistry and Assaying, University of Wisconsin.

TRUE, Rodney Howard, Washington, D. C.

B. S. (Wisconsin); Ph. D. (Leipzig).

TURNEAURE, Frederick Eugene, University Ave., Madison.

C. E. (Cornell). Professor of Bridge and Sanitary Engineering and Dean of the College of Engineering, University of Wisconsin.

TURNER, Frederick Jackson, 629 Francis St., Madison.

A. B., A. M. (Wisconsin); Ph. D. (Johns Hopkins). Professor of American History, University of Wisconsin; Member of Council, American Historical Association.

UIHLEIN, August, 332 Galena St., Milwaukee.

President, Second Ward Savings Bank; Secretary, Jos. Schlitz Brewing Company.

UPDIKE, Eugene Grover, 148 Langdon St., Madison.

B. S., M. S., D. D. (Lawrence). Pastor, First Congregational Church.

UPHAM, Arthur Aquila, 106 Conger St., Whitewater.

Professor of Natural Sciences, State Normal School.

VAN VELZER, Charles Ambrose, 134 W. Gorham St., Madison.

B. S. (Cornell); Ph. D. (Hillsdale). Professor of Mathematics, University of Wisconsin.

VIEBAHN Charles Frederick, 703 Western Av., Watertown.

Superintendent of Schools and Principal of High School.

VOGEL, Guido Charles, Milwaukee.

B. S. (Wisconsin).

Voss, Ernst Karl Johann Heinrich,
23 E. Johnson St., Madison.

Ph. D. (Leipzig). Professor of German Philology, University of Wisconsin.

WADMOND, Samuel C., 312 N. First St., Minneapolis, Minn.

Assistant Manager, Racine–Sattley Manufacturing Company.

WAGNER, George, 15 W. Gorham St., Madison.

Ph. C. (Michigan); A. B. (Kansas); A. M. (Michigan). Instructor in Zoology, University of Wisconsin.

WARD, Henry Levi, Milwaukee Public Museum, Milwaukee.

Custodian, Milwaukee Public Museum.

WATSON, Walter S., Whitewater.

Ph. B., M. S. (Wesley). Professor of Biology and German, State Normal School.

WEIDMAN, Samuel, 229 W. Gilman St., Madison.

B. S., Ph. D. (Wisconsin). Geologist, Wisconsin Geological and Natural History Survey.

WHITCOMB, Annabell Cook (Mrs. Henry F.), 721 Franklin St., Milwaukee.

President, Board of Directors of Boys' Busy Life Club.

WHITSON, Andrew Robinson, 420 Charter St., Madison.

B. S. (Chicago). Professor of Agricultural Physics, University of Wisconsin; Expert in Irrigation, U. S. Department of Agriculture.

WILSON, William M., No. 416 U. S. Post Office Bldg., Milwaukee.

Section Director, U. S. Department of Agriculture, Climate and Crop Service of the Weather Bureau.

WINSLOW, John Bradley, 131 Langdon St., Madison.

A. B., A. M. (Racine); LL. B., LL. D. (Wisconsin). Justice, Supreme Court of Wisconsin; President, Board of Visitors, University of Wisconsin; Trustee, Racine College.

WINGATE, Uranus O. B., 204 Biddle St., Milwaukee.

M. D. (Dartmouth). Professor of Nervous and Mental Diseases, Wisconsin College of Physicians and Surgeons.

WINKENWERDER, Hugo August, Sheboygan.

B. S. (Wisconsin). Instructor in Biology, Sheboygan High School.

WOLCOTT, Edson Ray, Golden, Colo.

B. S., M. S. (Wisconsin). Professor of Physics, Colorado School of Mines.

WOLFF, Henry C., 504 W. Washington Ave., Madison.

B. S., M. S. (Wisconsin). Instructor in Mathematics, University of Wisconsin.

WOLL, Fritz Wilhelm, 424 Charter St., Madison.

B. S., Ph. B. (Christiania); M. S., Ph. D. (Wisconsin). Assistant Professor of Agricultural Chemistry and Chemist to the Agricultural Experiment Station, University of Wisconsin.

WRIGHT, Clement Blake Bergin, 796 Astor St., Milwaukee.

A. B., A. M. (Trinity); B. D. (Nashotah); Ph. D. (Kansas City); F. S., Sc. (London, Eng.); F. R. S. L. Clergyman; Secretary, Diocese of Milwaukee; Librarian, Diocesan Library; Examining Chaplain; Editor, Church Times.

YOUTZ, Lewis Addison, Appleton.

Ph. B. (Simpson); Ph. D. (Columbia). Professor of Chemistry, Lawrence University.

ZIMMERMAN, Charles Frederick A., 622 Otjen St., Milwaukee.

Ph. B. (Illinois Wesleyan); A. M. (Charles City). Principal, Seventeenth District School.

ZIMMERMAN, Oliver Bruner, 222 Charter St., Madison.

B. M. E., M. E. (Wisconsin). Assistant Professor of Machine Design and Descriptive Geometry, University of Wisconsin; President, Wisconsin Audubon Society.

CORRESPONDING MEMBERS.

ABBOTT, Charles Conrad, Trenton, N. J.

M. D. (Pennsylvania).

ANDREWS, Edmund, 100 State St., Chicago, Ill.

A. B., A. M., M. D., LL. D. (Michigan). Professor of Clinical Surgery, Northwestern University; Surgeon, Mercy Hospital; Consulting Surgeon, Michael Reese Hospital and Illinois Hospital for Women and Children.

ARMSBY, Henry Prentiss, State College, Pa.

B. S. (Worcester Polytechnic); Ph. B., Ph. D. (Yale); LL. D. (Wisconsin). Director of Experiment Station; Expert in Animal Nutrition, U. S. Department of Agriculture.

BASCOM, John, Park St., Williamstown, Mass.

A. B., A. M. (Williams); D. D. (Iowa); LL. D. (Amherst, Williams). Greylock Commissioner.

BENNETT, Charles Edwin, 1 Grove Place Ithaca, N. Y.

A. B. (Brown). Professor of Latin Language and Literature, Cornell University; Examiner in Latin, College Entrance Examination Board.

BRIDGE, Norman,
217 S. Broadway, Los Angeles, Cal.; October each year, Rush Medical College, Chicago, Ill.

A. M. (Lake Forest); M. D. (Northwestern, Rush). Emeritus Professor of Medicine, Rush Medical College.

CAVERNO, Charles, Lombard, Ill.

A. B., A. M. (Dartmouth); LL. D. (Colorado). Clergyman, retired.

COULTER, John Merle, University of Chicago, Chicago, Ill.

A. B., A. M., Ph. D. (Hanover); Ph. D. (Indiana). Head Professor of Botany, University of Chicago.

CROOKER, Joseph Henry, 110 N. State St., Ann Arbor, Mich.

D. D. (St. Lawrence, Nashville). Minister, Unitarian Church.

DAVIS, Floyd, 317 Iowa Loan and Trust Bldg., Des Moines, Ia.

Ph. B., C. E., E. M. (Missouri); Ph. D. (Miami). Analytical and Consulting Chemist.

ECKELS, William Alexander, Oxford, Ohio.

A. B., A. M. (Dickinson); Ph. D. (Johns Hopkins). Professor of Greek, Miami University.

FALLOWS, Samuel, 967 W. Monroe St., Chicago, Ill.

A. B., A. M., LL. D. (Wisconsin); D. D. (Lawrence, Marietta). Presiding Bishop of the Reformed Episcopal Church; President of Board of Managers, Illinois State Reformatory.

HENDRICKSON, George Lincoln, 5515 Woodlawn Av., Chicago.

A. B. (Johns Hopkins). Professor of Latin, University of Chicago.

HIGLEY, William Kerr, Lincoln Park, Chicago, Ill.

Ph. M. (Michigan). Secretary, Chicago Academy of Sciences; Editor, Birds and Nature.

HODGE, Clifton Fremont, 3 Charlotte St., Worcester, Mass.

A. B. (Ripon); Ph. D. (Johns Hopkins). Assistant Professor of Physiology and Neurology, and Professor of Biology in the Collegiate Department, Clark University.

HOLDEN, Edward Singleton, U. S. Military Academy, West Point, N. Y.

B. S., A. M. (Washington); S. D. (Pacific); LL. D. (Wisconsin and Columbia). Astronomer.

HOLLAND, Frederic May, Main St., Concord, Mass.

A. B. (Harvard).

HOSKINS, Leander Miller, 365 Lincoln Av., Palo Alto, Cal.

M. S., C. E. (Wisconsin). Professor of Applied Mathematics, Leland Stanford Jr. University.

IDDINGS, Joseph Paxson, 5730 Woodlawn Av., Chicago, Ill.

Ph. B. (Yale). Professor of Petrology, University of Chicago.

KINLEY, David, Urbana, Ill.

A. B. (Yale); Ph. D. (Wisconsin). Dean of the College of Literature and Arts, and Professor of Economics, University of Illinois.

LEVERETT, Frank, Ann Arbor, Mich.

B. Sc. (Iowa Agricultural). Geologist, U. S. Geological Survey.

LURTON, Freeman Ellsworth, Preston, Minn.

B. S., M. S. (Carleton); Ph. D. (Gale). Superintendent of Public Schools.

LUTHER, George Elmer, 260 S. College Av., Grand Rapids, Mich.

Cashier, Peoples Savings Bank, Treasurer, Historical Society of Grand Rapids; President, Board of Poor Commissioners of Grand Rapids.

MARX, Charles David, Palo Alto, Cal.

B. C. E. (Cornell); C. E. (Carlsruhe). Professor of Civil Engineering, Leland Stanford Jr. University.

McCLUMPHA, Charles Flint, Minneapolis, Minn.

A. B., A. M. (Princeton); Ph. D. (Leipzig). Professor of English Language and Literature, University of Minnesota.

MOOREHOUSE, George Wilton, 842 Logan Av., Cleveland, O.

B. L., M. L. (Wisconsin); M. D. (Harvard). Physician to the Dispensary of Lakeside Hospital and Western Reserve University.

PEET, Stephen Denison, 5817 Madison Av., Chicago.

A. M., Ph. D. (Beloit). Clergyman; Editor, American Antiquarian and Oriental Journal.

POTTER, William Bleecker, 1225 Spruce St., St. Louis, Mo.

A. B., A. M., M. E. (Columbia). Mining Engineer and Metallurgist.

POWER, Frederick Belding, 535 Warren St., Hudson, N. Y.

Ph. G. (Phila. Coll. of Pharm.); Ph. D. (Strassburg). Director of Wellcome Chemical Research Laboratories, London, Eng.

RAYMOND, Jerome Hall, University of Chicago, Chicago, Ill.

A. B., A. M. (Northwestern); Ph. D. (Chicago). Associate Professor of Sociology, University of Chicago.

SALISBURY, Rollin D., University of Chicago, Chicago, Ill.

A. M. (Beloit). Professor of Geographic Geology; Head of the Department of Geography, and Dean of the Graduate School of Science, University of Chicago; Geologist, U. S. Geological Survey and State Geological Survey of New Jersey.

SAWYER, Wesley Caleb, Elm and Asbury Sts., San Jose, Cal.

A. B., A. M. (Harvard); A. M., Ph. D. (Göttingen). Professor of French and German and Lecturer on Teutonic Mythology, University of the Pacific.

SHIPMAN, Stephen Vaughn, 269 Warren Ave., Chicago, Ill.

Colonel U. S. Volunteers, Civil War; Architect.

STONE, Ormond, University Station, Charlottesville, Va.

M. A. (Chicago). Director of the Leander McCormick Observatory and Professor of Practical Astronomy, University of Virginia.

TATLOCK, John, Jr., 32 Nassau St., New York, N. Y.

A. B., A. M. (Williams); F. R. A. S. Assistant Actuary, Mutual Life Insurance Co.

TOLMAN, Albert Harris, 5750 Woodlawn Av., Chicago, Ill.

B., A. M. (Williams); F. R. A. S. Assistant Actuary, Mutual Life Literature, University of Chicago.

TOLMAN, Herbert Cushing, Nashville, Tenn.

A. B., Ph. D. (Yale); D. D. (Nashville). Professor of Greek, Vanderbilt University.

TOWNLEY, Sidney Dean, Ukiah, Cal.

B. S., M. S. (Wisconsin); S. D. (Michigan). Observer in charge of International Latitude Observatory; First Vice-President of the Astronomical Society of the Pacific.

Trelease, William, Botanical Garden, St. Louis, Mo.

B. S. (Cornell); S. D. (Harvard); LL. D. (Wisconsin, Missouri). Director of Missouri Botanical Garden and Henry Shaw School of Botany; Engelmann Professor of Botany, Washington University; Vice-President, Academy of Science of St. Louis; Secretary, The Round Table, St. Louis; Honorary President, Engelmann Botanical Club, St. Louis.

Van de Warker, Ely, 404 Fayette Park, Syracuse, N. Y.

M. D. (Albany Medical and Union). Surgeon Central New York Hospital for Women; Consulting Physician St. Ann's Maternity Hospital; Senior Surgeon Women's and Children's Hospital; Commissioner of Education, Syracuse; Member of the Holland Society.

Van Vleck, Edward Burr, Middletown, Conn.

A. B., A M. (Wesleyan); Ph. D. (Göttingen). Professor of Mathematics, Wesleyan University.

Verrill, Addison Emory, 86 Whalley Av., New Haven, Conn.

S. B. (Harvard); A. M. (Yale). Professor of Zoölogy, Yale University; Curator of Zoology, Yale University Museum; President, Connecticut Academy of Arts and Sciences.

Winchell, Newton Horace, 113 State St., Minneapolis, Minn.

A. M. (Michigan). Editor of the American Geologist.

Young, Albert Adams, 531 S. Claremont Av., Chicago, Ill.

A. B., A. M. (Dartmouth); D. B. (Andover). Clergyman; Member of the Chicago Academy of Science.

MEMBERS DECEASED.

Information of whose decease has been received since the issue of volume XIII.

HASTINGS, Samuel Dexter, April, 1903, at Evanston, Ill.

Ex-Treasurer of the State of Wisconsin; ex-Secretary of State Board of Charities; ex-Treasurer, Wisconsin Academy of Sciences, Arts and Letters.

TIMBERLAKE, Hamilton Greenwood, July 19, 1903, at Madison.

Assistant Professor of Botany, University of Wisconsin.

PABST, Frederick, January 1, 1904, at Milwaukee.

President, Pabst Brewing Company.

JEGI, John I., January 7, 1904, at Milwaukee.

Professor of Physiology and Psychology, State Normal School; Vice-President, Wisconsin Academy of Sciences, Arts and Letters.

MITCHELL, John Lendrum, June 30, 1904, at Milwaukee.

Ex-United States Senator.

PROCEEDINGS.

REPORT OF THE SECRETARY, 1902.

The thirty-third annual meeting was held in the lecture room of the Historical Library Building, Friday and Saturday, December 26 and 27, 1902. The meeting was called to order at 9:15 A. M. by President Slichter. About thirty members were present, and this number was increased to near forty before the close of the forenoon. The average attendance at the four sessions was about thirty-five. In all about forty-five members were present. The following program was carried out with no change except in the order of the papers and the omission of Nos. 12, 14, 15, 16 and 28, which were omitted on account of the absence of the authors:

FRIDAY, DECEMBER 26.

Morning Session, 9:00 O'clock.

Reading of papers at 9:15.

1. Fluoride of gold. *Victor Lenher.*
2. Some new tellurium compounds. *Victor Lenher.*
3. Glycerophosphoric acid and glycerophosphates. *Edward Kremers.*
4. Action of metallic magnesium upon aqueous solutions. *Louis Kahlenberg.*
5. Action of sodium amalgam upon aqueous solutions. *Gustave Fernekes.*
6. Action upon metals of solutions of hydrochloric acid in various solvents. *Harrison E. Patten.*
7. The quantitative determination of antimony. *Lewis A. Youtz.*
8. Notes on the red slate deposit of southwestern Arkansas. *W. W. Daniells.*

Afternoon Session, 2:30 O'clock.

9. The relations of metamorphism to the redistribution of the chemical elements. *Charles R. Van Hise.*

10. The erosion history of southwestern Wisconsin. *Ellwood C. Perisho.*

11. On a record of post Newark subsidence and subsequent elevation within the area of southwestern New England. *W. H. Hobbs.*

12. Notes on the Kansas City pre-historic skeleton. *Daniel Folkmar.*

13. New or little known extinct vertebrates from the Permian Beds of Texas. *E. C. Case.*

14. Prehistoric migrations into the territory now comprising the state of Wisconsin. *Stephen D. Peet.*

15. Chloroform and consciousness. *C. Caverno.*

16. Incipient pseudopeia. *C. Caverno.*

Evening Session at the Unitarian Church.

Academy banquet complimentary to visiting members at 6:30 o'clock.

Address of the retiring president, Professor Charles Sumner Slichter of the University of Wisconsin, at 8:00 o'clock, on "Recent criticism of American scholarship."

SATURDAY, DECEMBER 27.

Morning Session, 9:00 O'clock.

Election of officers and other business.

Reading of papers at 9:30 o'clock.

17. Nuclear fusion and nuclear division in a mildew, Phyllactinia suffulta. *R. A. Harper.*

18. Observation on cell structure and nuclear division in masses. *Charles E. Allen.*

19. Attidae of South Africa. *G. W. and E. G. Peckham.* (By title.)

20. Ten species of Arrenuri belonging to the subgenus megalurus Thon. *Ruth Marshall.*

21 On variations in form and size of Cyclops brevispinosus Herrick and Cyclops Americanus Marsh. *Harriet Lehmann.*

22. Three cases of pancreatic bladder in the cat. *W. S. Miller.*

23. The pancreatic ducts of the cat. *G. H. Heuer.*

24. Variation and individuality in the pyloric caeca of the rock bass. *R. H. Johnson.*

25. Variation and correlation in necturus maculatus. *E. G. Birge.*

26. A parisitic Ostracod. *W. S. Marshall.*

27. Some notes on the food and on the parasites of a few freshwater fish. *W. S. Marshall.*

Afternoon Session.

28. Language at the age of four. *John I. Jegi.*

29. The vocabulary of Shakespeare. *Edward T. Owen.*

Memorial Addresses:

George McKendree Steele—*Samuel Plantz.*

John Butler Johnson—*F. E. Turneaure.*

Charles Kendall Adams—*C. F. Smith.*

A very pleasant feature of the meeting was the banquet complimentary to the visiting members, held in the Unitarian church on Friday evening. Forty persons were present at the banquet, including nine visiting members, twenty-four resident members and seven guests. Short after dinner speeches were made by Messrs. Birge, Marsh, Davis, Perisho and Case. At 8 o'clock the company repaired to the parlor of the church to listen to the excellent address of the retiring president on "Recent Criticism of American Scholarship."

A detailed account of the morning and afternoon sessions is herewith given:

FRIDAY, DECEMBER 26.

Morning Session.

President Slichter in the chair.

The secretary's report was read and ordered placed on file. The following is a brief synopsis of the report.

The first item of business was the report of the Secretary. After indicating that the minutes of the last meeting had been published in Vol. XIII of the Transactions, the report men-

tioned the fact that during the year Part II of Vol. XIII had been printed and distributed, and that preparations were under way for the publication of the first part of Vol. XIV. Attention was called to the fact that during the administration of President Slichter some important changes had been effected by which the cost of all illustrations are now borne by the state and that illustrations made by the most approved processes had been furnished. Mr. A. A. Meggett, printing clerk, during this period, rendered efficient service in securing these ends.

The report spoke also of the fact that a greater effort had been made to bring the work of the Academy to the notice of the people of the state than had been made heretofore. Prior to the meetings of 1901 and 1902 about one thousand programs, each accompanied by a card of invitation, had been sent out principally to persons engaged in educational work.

The report of the librarian was read and ordered filed. It appears in full below.

Papers 1 and 2 were then read. These papers were discussed by Messrs. Kahlenberg, Atherton and Hillyer.

Papers 4, 5 and 6 were all read by Professor Kahlenberg. They were further discussed by Messrs. Kremers, Lenher and Hillyer. No. 7 was deferred till the afternoon, as the author was unable to reach Madison in time for the morning session. The reading of papers for the morning was concluded with No. 8. The treasurer's report was then read. Messrs. C. H. Chandler and W. S. Miller were appointed as auditing committee. The report is printed in full below.

Afternoon Session.

Papers 9, 10 and 11 were read and No. 10 was discussed by Messrs. Van Hise and Hobbs. No. 13 was next read and Nos. 12, 14, 15 and 16 were omitted owing to the absence of the authors. Paper 7 was read at this point and discussed by Professor Lenher.

The president announced the appointment of Messrs. Kahlenberg, Marsh and Case as a nominating committee, with instructions to report Saturday morning.

SATURDAY, DECEMBER 27.

Morning Session.

The auditing committee reported that they had examined the books of the Treasurer and found them correct in every respect.

The following resolution, offered by Professor Marsh, was unanimously adopted.

Resolved, That the Academy hereby appropriates the sum of seventy-five dollars per annum as an allowance for secretary's expenses, for which a single voucher shall be required.

The nominating committee reported the following nominees: nees:

For President, John J. Davis.

For Vice-Presidents, Charles H. Chandler, John I. Jegi, Dexter P. Nicholson.

For Secretary, Ernest B. Skinner.

For Treasurer, Homer W. Hillyer.

For Librarian, Walter M. Smith.

For Curator, Ellwood C. Perisho.

For Publication Committee, the President and the Secretary, *ex-officio,* A. S. Flint.

For Library Committee, the Librarian, *ex-officio,* C. Dwight Marsh, George W. Peckham, Hiram D. Densmore and Reuben G. Thwaites.

For Membership Committee, the Secretary, *ex-officio,* Rufus H. Halsey, Ermine C. Case, W. J. Starr, Louis Kahlenberg.

It was voted that the Secretary be ordered to cast the ballot of the Academy for the persons nominated and when the ballot was reported cast, they were declared elected to the several offices named.

The membership committee reported, recommending the election of the following persons to active membership:

Mr. W. M. Wilson, Milwaukee.

Professor Frederick Eugene Turneaure, Madison.

Mr. Hugo Albert Pauly, Madison.

Professor Victor Coffin, Madison.

Mr. Charles Newton Brown, Madison.

Mr. Winfield G. Scott, Racine.

Mr. Samuel C. Wadmond, Racine.

Professor Frank Morton Erickson, Ripon.
Professor Hubert Gibson Shearin, Ripon.
Mr. A. Herman Pfund, Madison.
Mr. A. B. Newell, Madison.
Mr. Wiley Jerome Huddle, Madison.
Mr. Charles Austin Tibbals, Madison.
Mr. Henry F. Kling, Evansville.
Mr. Edward Grant Birge.
Miss Harriet Lehmann, Neosho.
Professor Lewis Addison Youtz, Appleton.
Mr. Herbert John Farley, Appleton.
Mr. Lewis Oliver Atherton, Oshkosh.
Rev. Clement Blake Bergin Wright, Milwaukee.
Mr. Charles E. Brown, Milwaukee.
Judge John B. Winslow, Madison.

The secretary was ordered to cast the ballot of the Academy for these persons and they were declared elected.

The committee also recommended that Professor Charles Sumner Slichter, past president, and Professor Frank Chapman Sharp, past secretary, be elected life members in view of their services to the Academy.

This recommendation was voted by the Academy.

Paper No. 25 was placed first on the program for the morning and No. 26 was read by title. Otherwise the program for the remainder of the forenoon was carried out as printed. No. 21 was discussed by Messrs. Harper and Marsh, No. 23 by Professor Miller, and No. 25 by Professor Miller and Mr. R. H. Johnson.

Afternoon Session.

Paper No. 28 was omitted, the author having been called away from Madison. No. 29 was discussed at length by Professor Hubbard. The address in memory of the late President Adams was prepared and read by Professor Charles Foster Smith instead of Dr. E. A. Birge as announced on the program.

Dr. Davis, president elect, was called to the chair and made a few appropriate remarks. The Academy then adjourned *sine die*.

E. B. Skinner,
Secretary.

REPORT OF SECRETARY, 1903.

Thirty-Fourth Annual Meeting.

Milwaukee, Wis., Dec. 29–30, 1903.

The meetings of the Academy were held in Room B—3 of the Milwaukee Normal School building. The following program was carried out with some changes in the order of the papers:

Tuesday, December 29.

Morning Session, 10:30 o'clock.

Reports of officers and general business.

Reading of papers.

1. A query concerning the longevity of college graduates. *Chas. H. Chandler.*
2. A problem in conformal representation. *H. C. Wolff.*
3. The probable accuracy of estimates and guesses. *E. F. Chandler.*
4. A simple treatment of the relative angular and linear velocities in complex mechanisms. *O. B. Zimmerman.*
5. Waves peculiar to ground water movements. *C. S. Slichter.*
6. An apparatus designed for teaching celestial geography. *W. L. Rankin.*

Afternoon Session, 2:00 o'clock.

7. The collective theory of mind. *S. Plantz.*
8. Auditory memory-span for numbers in school children. *John I. Jegi.*
9. How children learn to spell. *C. E. Patzer.*
10. A Wisconsin group of German poets. *Henry E. Legler.*
11. Some factors in the pejoration of English words. *W. G. Bleyer.*
12. The quinhydrone hypothesis of plant pigmentation. *Edward Kremers.*

13. The Monardas: a comparative study of their vo
stituents. *I. W. Brandel.*

14. On the nature of osmosis and osmotic pressure.
lenberg.

15. On the composition of underground waters in t
boo iron region. *W. W. Daniells.*

16. Erosion in southwestern Wisconsin. *E. C. Per*

17. An interesting fossil Unio from Wisconsin.
Wagner.

18. An exhibition of fossil vertebrates from the L
Beds of Texas. *E. C. Case.*

19. An exhibition of a relief model of Milwaukee an
ity. *E. C. Case.*

WEDNESDAY, DECEMBER 30.

Morning Session, 9:00 o'clock.

General business.

Reading of papers.

20. Some Hepaticae of the Apostle Islands. *C. E.*
(By title.)

21. Migrating nuclei in anthers of Lilium Canadense.
Allen.

22. The structure of the starch grain. *R. H. Dennist*

23. Mushrooms considered from a scientific and comm
standpoint. *Frank A. Thompson.*

24. Variations of the brachial and sacral plexus of the
G. A. Talbert.

25. Variations in the appendages of the frog. *G. A. Ta*

26. A clinical study of cerebral localization. *G. A. Tal*

27. Report of a case of hydrophobia. *Otto Fiedler.*

Memorial addresses:

Samuel Dexter Hastings—*J. B. Parkinson.*

Hamilton Greenwood Timberlake—*R. A. Harpe*

Afternoon Session, 2:00 o'clock.

28. Some Cladocera of South America. *Harriet B. Merrill.*

29. Some new Diaptomi from the western states. *C. Dwight Marsh.*

30. A new Arrenurus and notes on collections. *Ruth Marshall.*

31. The birds seen on a Milwaukee home garden in 1903. *I. N. Mitchell.*

32. The summer birds of Stony Lake, Oceana County, Michigan. *I. N. Mitchell.*

33. On Milwaukee County Odonata. *Charles E. Brown.*

34. The re-awakening of the interest in Wisconsin antiquities. *Henry A. Crosby and Charles E. Brown.*

35. A study in the variation of proportions in bats. *Henry L. Ward.*

36. The Polyporeae of Wisconsin. *J. J. Neumann.* (By title.)

37. Saskatchewan Birds. *Russell T. Congdon.* (By title.)

38. Conformal representation of plane curves, particularly for the cases, p = 4, 5 and 6. *Charlotte E. Pengra.* (By title.)

39. Shakespeare as a cicerone in girdling the globe. *James Davie Butler.* (By title.)

A more detailed account of the various sessions is given below:

TUESDAY, DECEMBER 29.

Morning Session.

The Academy was called to order at 10:30 by President Davis. The reading of the minutes of the last session was dispensed with. The Secretary reported that since the last meeting Volume XIV, Part I, of the Transactions of the Academy, containing fifteen papers and thirty-three plates, had been published and distributed. He reported also that the printing commissioners had permitted the employment of engravers outside of the state, a circumstance which would allow much greater choice of methods in the re-production of illustrations for papers printed in the Transactions. The Secretary asked that the Academy define the term, Secretary's expenses, in the resolution of December 27, 1903. He asked also that a committee

be appointed to determine the status of corresponding members, stating at the same time that under the present practice, the rights and privileges of such members are practically the same as those of life and honorary members. A preliminary report of the Treasurer was read. This report showed that there are at present 187 paying members on the roll. The report further showed that the amount of the permanent fund now invested in Madison street improvement bonds is $1,614.40; that during the year the receipts have been $367.25 and expenditures $233.73, leaving a balance in the treasury of $133.52. The Treasurer asked for the appointment of an Auditing committee who shall in the near future examine the detailed report. By vote the Council was authorized to accept the report for publication when approved by the Auditing committee. The President appointed as Auditing committee Messrs. Slichter, Flint, and C. E. Allen.

The Treasurer recommended the dropping of certain members for non-payment of dues. This matter was referred to the Secretary and the Treasurer with power to act under the resolution of December 29, 1892.

The reading of papers was taken up at this point. The first paper was discussed by Messrs. Davis and Flint. Nos. 2, 3 and 4 were discussed by Messrs. Slichter, Chandler, Skinner, and others.

About eighteen persons were in attendance at the morning session.

Afternoon Session.

President Davis was in the chair. The session began with the reading of the paper of President Plantz. The papers of the afternoon were read for the most part without discussion. Owing to the absence of the authors, Nos. 12, 14 and 16 were omitted. The meeting adjourned to the physiographic laboratory of the Normal School to listen to the reading of papers 18 and 19.

The attendance at the afternoon session reached a total of some sixty persons.

WEDNESDAY, DECEMBER 30.

Morning Session.

The Membership committee reported recommending the following persons for membership in the Academy:

Henry Levi Ward, Milwaukee.
Carl Spencer Milliken, Ripon.
Oliver Jones Marston, Ripon.
Conrad E. Patzer, Milwaukee.
Harold B. Shinn, Menomonie.
Dana Carlton Munro, Madison.
Jonathan Risser, Beloit.
George Wagner, Madison.
Russell T. Congdon, Ripon.
Otto Fiedler, Milwaukee.
Henry A. Crosby, Milwaukee.
William Joshua Brinckley, Appleton.

The ballot of the Academy was ordered cast by the Secretary and the persons named were declared elected to active membership.

Professor Flint introduced an amendment to the constitution which would make the first clause of Article VII to read, "The annual meeting of the Academy shall be held at such time and place as the Council may designate."

The reading of papers was then taken up. Professor Kahlenberg, who had not been able to be present on Tuesday, presented his paper on the Theory of Osmosis. This paper dealing with a very important subject, was discussed at length by the President, Messrs. Wagner, Flint and others. No. 21 was discussed by the President and Professor Kahlenberg, both of whom expressed the opinion that the forces acting in this case might be akin to the forces discussed by Professor Kahlenberg. Professor Talbert's papers evoked discussion by Messrs. Wagner and Marshall. Nos. 22, 27 and the memorial address for Professor Timberlake were omitted owing to the absence of the author. The address for Mr. Hastings was read by Professor Kahlenberg.

Afternoon Session.

The afternoon session was devoted in large measure to the discussion of zoological topics. Professor Marsh's paper represented in a manner the continuation of work already published in the Transactions. The same is also true of the work of Miss Marshall. Nos. 31 and 32 were of considerable popular interest. In No. 33 Mr. Brown presented the results of several years' collections by himself and others in the immediate vicinity of Milwaukee. No. 34 was a plea for a larger interest in Wisconsin Antiquities and the work of the Wisconsin Archaeological Society. Mr. Ward presented in No. 35 much interesting data in the measurements of bats. The paper was discussed by Dr. Kahlenberg.

Resolutions thanking Mr. W. F. Sell, railway manager of the State Teachers' Association, and the authorities of the Milwaukee Normal School for courtesies extended to the Academy were introduced by Professor Flint, and passed by unanimous vote.

The Academy adjourned *sine die*.

E. B. Skinner,
Secretary.

REPORTS OF THE TREASURER.

REPORT OF THE TREASURER, 1902.

During the past year one hundred forty-one members have paid dues for one or more years. There are thirty-five members in arrears for one year, two for two years, five for three years and three for four years. In accordance with the custom of the Academy the names of those who are now in arrears for four years will be read that they may be stricken from the rolls unless cause is shown for retaining them. The total number on the rolls is now one hundred eighty-three.

The accounts for the year 1902 stand as follows:

Receipts.

1901. Dec. 27.	Balance on hand in general fund.....	$17 20
1902. May 3.	Interest on permanent fund.....	70 00
1902. Dec. 27.	Receipts from dues	169 00
	Total receipts	$256 20
1902. Apr. 23.	Transferred to permanent fund.....	106 40
	Balance in general fund.....	$149 80

Expenditures.

Vouchers Nos.		
1, 10, 15	Secretary, incidental expenses.....	$19 48
2, 14, 17	Clerk hire	13 20
5, 16	Printing	32 25
6	Express	25
7	Typewriting	5 97

Voucher Nos.		
4, 8, 9	Stationery	5 20
2, 10', 12, 13	Postage	15 75
	Total expenditures	$92 10
	Net balance general fund.....	149 80
	Balance on hand.....	$57 70
	Balance in permanent fund.....	1,614 40
	Grand total	$1,672 10

The permanent fund of the Academy is now invested in fifteen Madison City Special Street Improvement bonds of one hundred dollars each. These bonds are now at a premium and draw about 4.6 per cent. interest on the investment.

Respectfully submitted,

H. W. HILLYER,
Treasurer.

The undersigned, auditing committee on the report of the Treasurer, have examined said report and vouchers submitted therewith and find it correctly vouched and balanced.

CHAS. H. CHANDLER,
WM. S. MILLER,
Auditing Committee.

REPORT OF THE TREASURER, 1903.

The Treasurer of the Academy begs to submit the following report:

There are on the roll of the Academy as paying members one hundred eighty-seven persons. In accordance with the by-laws of the Academy a list of names of those members more than two years in arrears is herewith presented to be read to the Academy. The names of such persons may, under the resolution of December, 1892, be stricken from the roll.

The account of the academy stands as below:

Receipts.

Balance in General fund	**$58 70**
Interest on Permanent fund	**90 00**
Membership and initiation dues	**197 00**
Insurance, $.55; and sales, $1.00	**1 55**
Total receipts	**$347 25**

Expenditures.

No. of Voucher.		
1	E. B. Skinner	$17 15
1, 10	Tracy, Gibbs & Co.	55 75
2	Capital City Paper Co.	4 33
3	Photographs of past presidents	30 00
4, 5-5′, 8, 11	Postage	14 00
6	A. Haswell & Co	8 20
7	W. T. Leonard	21 30
9	E. B. Skinner	75 00
	Total expenditures	$225 73
	Balance in General fund	121 52
	Permanent fund	1,614 40
	Grand Total	$1,735 92

Respectfully submitted,

H. W. Hillyer,
Treasurer.

The undersigned, appointed to audit the accounts of the treas-

The undersigned, appointed to audit the accounts of the Treasurer, find them correct in every particular.

Charles S. Slichter,
Albert S. Flint,
Auditing Committee.

REPORTS OF THE LIBRARIAN.

REPORT OF THE LIBRARIAN, 1902.

Since the last report, the work done on the library of the Academy has consisted largely of the regular distribution of the Transactions of the Academy, the acknowledging of the exchanges received, and the binding of the latter. Three hundred and five volumes have recently been bound. The work of getting the books ready for the bindery is greatly retarded by the fact that back numbers belonging to some of the volumes are lacking and must first be secured. Members of the Academy having in their possession any such unbound parts of volumes are earnestly requested to send them in as soon as possible.

It is a source of gratification that the library of the Academy is now safely housed and that its volumes are readily accessible. To W. M. Smith, Librarian of the University, who has superintended the work done on the library since its removal to the new building, the Academy is greatly indebted.

LOUIS KAHLENBERG,
Librarian.

Madison, December 26, 1902.

REPORT OF THE LIBRARIAN, 1903.

The ordinary routine work connected with the library of the Academy has been performed the past year as heretofore, but press of work in other directions has prevented the librarian from carrying out as yet plans to increase greatly the value and efficiency of the library. A thorough revision of the exchange

list is needed and a systematic effort should be made to extend our exchange relations. It is planned to take up this work during the coming year, in connection with similar efforts on the part of the Wisconsin State Historical Society and the Library of the University of Wisconsin, and the librarian hopes to be able to record in his next report substantial progress in this and other directions.

While it has not been feasible as yet to recatalogue the library, the collection is so arranged as to be thoroughly accessible to all members and other students.

WALTER M. SMITH,
Librarian.

Madison, Wis., December 26, 1903.

EXTRACTS FROM THE CHARTER.

AN ACT to incorporate the Wisconsin Academy of Sciences, Arts, and Letters.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. Lucius Fairchild, Nelson Dewey, John W. Hoyt, Increase A. Lapham, * * *[1] at present being members and officers of an association known the "The Wisconsin Academy of Sciences, Arts, and Letters," located at the city of Madison, together with their future associates and successors forever, are hereby created a body corporate by the name and style of the "Wisconsin Academy of Sciences, Arts and Letters," and by that name shall have perpetual succession; shall be capable in law of contracting and being contracted with, of suing and being sued, of pleading and being impleaded in all courts of competent jurisdiction; and may do and perform such acts as are usually performed by like corporate bodies.

SECTION 2. The general objects of the Academy shall be to encourage investigation and disseminate correct views in the various departments of science, literature, and the arts. Among the specific objects of the Academy shall be embraced the following:

1. Researches and investigations in the various departments of the material, metaphysical, ethical, ethnological, and social sciences.

2. A progressive and thorough scientific survey of the state with a view of determining its mineral, agricultural, and other resources.

3. The advancement of the useful arts, through the applications of science, and by the encouragement of original invention.

4. The encouragement of the fine arts, by means of honors and prizes awarded to artists for original works of superior merit.

5. The formation of scientific, economic, and art museums.

6. The encouragement of philological and historical research, the collection and preservation of historic records, and the formation of a general library.

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[1] Here follow the names of forty others. Sections 5, 6, 8, and 9 are here omitted as of no present interest. For the charter in full see *Transactions*, Vol. viii, p. xi, or earlier volumes.

7. The diffusion of knowledge by the publication of original contributions to science, literature, and the arts.

SECTION 3. Said Academy may have a common seal and alter the same at pleasure; may ordain and enforce such constitution, regulations, and by-laws as may be necessary, and alter the same at pleasure; may receive and hold real and personal property, and may use and dispose of the same at pleasure; *provided*, that it shall not divert any donation or bequest from the uses and objects proposed by the donor, and that none of the property acquired by it shall, in any manner, be alienated other than in the way of exchange of duplicate specimens, books, and other effects, with similar institutions and in the manner specified in the next section of this act, without the consent of the legislature.

SECTION 4. It shall be the duty of the said Academy, so far as the same may be done without detriment to its own collections, to furnish, at the discretion of its officers, duplicate typical specimens of objects in natural history to the University of Wisconsin, and to the other schools and colleges of the state.

SECTION 7. Any existing society or institution having like objects embraced by said Academy, may be constituted a department thereof, or be otherwise connected therewith, on terms mutually satisfactory to the governing bodies of the said Academy and such other society or institution.

Approved March 16, 1870.

EXTRACTS FROM THE WISCONSIN STATUTES.

STATUTES OF 1898.

TRANSACTIONS OF THE ACADEMY.

SECTION 341. There shall be printed by the state printer biennially in pamphlet form two thousand copies of the transactions of the Wisconsin Academy of Sciences, Arts, and Letters, uniform in style with the volumes heretofore printed for said society.

NOTE.—The Academy allows each author one hundred separates of his paper from the Transactions without expense to the author, except a small charge for printed covers when desired.—EDITOR.

CHAPTER 22.

OF THE DISTRIBUTION OF PUBLIC DOCUMENTS.

SECTION 365. The transactions of the Wisconsin Academy of Sciences, Arts, and Letters shall be distributed as follows: One copy to each member of the legislature, one copy to the librarian of each state institution; one hundred copies to the State Agricultural Society; one hundred copies to the State Historical Society; one hundred copies to the State University, and the remainder to said Academy.

SECTION 366. In the distribution of books or other packages, if such packages are too large or would cost too much to be sent by mail, they shall be sent by express or freight, and the accounts for such express or freight charges, properly certified to, shall be paid out of the state treasury.

STATUTES OF 1901.

CHAPTER 447.

BINDING OF EXCHANGES.

SECTION 1. Section 341 of the revised statutes of 1898 is hereby amended by adding thereto the following: The secretary of state may authorize the state printer to bind in suitable binding all periodicals and other exchanges which the Society shall hereafter receive, at a cost not exceeding one hundred and fifty dollars per annum. The secretary of state shall audit the accounts for such binding.

CONSTITUTION

OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS.

[As amended in Articles V, VI and IX at the regular meetings of December, 1899, and December, 1901.]

ARTICLE I.—*Name and Location.*

This association shall be known as the Wisconsin Academy of Sciences, Arts, and Letters, and shall be located at the city of Madison.

ARTICLE II.—*Object.*

The object of the Academy shall be the promotion of sciences, arts, and letters in the state of Wisconsin. Among the special objects shall be the publication of the results of investigation and the formation of a library.

ARTICLE III.—*Membership.*

The Academy shall include four classes of members, viz.: life members, honorary members, corresponding members, and active members, to be elected by ballot.

1. Life members shall be elected on account of special services rendered the Academy. Life membership in the Academy may also be obtained by the payment of one hundred dollars and election by the Academy. Life members shall be allowed to vote and to hold office.

2. Honorary members shall be elected by the Academy and shall be men who have rendered conspicuous services to science, arts, or letters.

3. Corresponding members shall be elected from those who have been active members of the Academy, but have removed from the state. By special vote of the Academy men of attainments in science or letters may be elected corresponding members. They shall have no vote in the meetings of the Academy.

4. Active members shall be elected by the Academy and shall enter upon membership on the payment of an initiation fee of two dollars which shall include the first annual assessment of one dollar. The annual assessment shall be omitted for the president, secretary, treasurer, and librarian during their term of office.

ARTICLE IV.—*Officers.*

The officers of the Academy shall be a president, a vice-president for each of the three departments, sciences, arts, and letters, a secretary, a librarian, a treasurer, and a custodian. These officers shall be chosen by ballot, on recommendation of the committee on nomination of officers, by the Academy at an annual meeting and shall hold office for three years. Their duties shall be those usually performed by officers thus named in scientific societies. It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

ARTICLE V.—*Council.*

The council of the Academy shall be entrusted with the management of its affairs during the intervals between regular meetings, and shall consist of the president, the three vice-presidents, the secretary, the treasurer, the librarian, and the past presidents who retain their residence in Wisconsin. Three members of the council shall constitute a quorum for the transaction of business, provided the secretary and one of the presiding officers be included in the number.

ARTICLE VI.—*Committees.*

The standing committees of the Academy shall be a committee on publication, a library committee, and a committee on the nomination of members. These committees shall be elected at the annual meeting of the Academy in the same manner as the other officers of the Academy, and shall hold office for the same term.

1. The committee on publication shall consist of the president and secretary and a third member elected by the Academy. They shall determine the matter which shall be printed in the publications of the Academy. They may at their discretion refer papers of a doubtful character to specialists for their opinion as to scientific value and relevancy.

2. The library committee shall consist of five members, of which the librarian shall be *ex officio* chairman, and of which a majority shall not be from the same city.

3. The committee on nomination of members shall consist of five members, one of whom shall be the secretary of the Academy.

ARTICLE VII.—*Meetings.*

The annual meetings of the Academy shall be held between Christmas and New Year, at such place as the council may designate; but all regular meetings for the election of the board of officers shall be held at Madison. Summer field meetings shall be held at such times and places as the Academy or the council may decide. Special meetings may be called by the council.

ARTICLE VIII.—*Publications.*

The regular publication of the Academy shall be known as its Transactions, and shall include suitable papers, a record of its proceedings, and any other matter pertaining to the Academy. This shall be printed by the state as provided in the statutes of Wisconsin. All members of the Academy shall receive gratis the current issues of its Transactions.

ARTICLE IX.—*Amendments.*

Amendments to this constitution may be made at any annual meeting by a vote of three-fourths of all the members present; *provided*, that the amendment has been proposed by five members, and that notice has been sent to all the members at least one month before the meeting.

RESOLUTIONS

REGULATIVE OF THE PROCEEDINGS OF THE ACADEMY.

THE TRANSACTIONS OF THE ACADEMY.

[*By the Academy, December 28, 1882. Transactions, Vol. VI, p. 350.*]

2. The secretary of the Academy shall be charged with the special duty of overseeing and editing the publication of future volumes of the Transactions.

3. The Transactions of the Academy hereafter published shall contain: (a) a list of officers and members of the Academy; (b) the charter, by-laws and constitution of the Academy as amended to date; (c) the proceedings of the meetings; and (d) such papers as are duly certified in writing to the secretary as accepted for publication in accordance with the following regulations, and no other.

6. In deciding as to the papers to be selected for publication, the committee shall have special regard to their value as genuine, original contributions to the knowledge of the subject discussed.

9. The Sub-Committee on Publication shall be charged with insisting upon the correction of errors in grammar, phraseology, etc., on the part of authors, and shall call the attention of authors to any other points in their papers, which their judgment appear to need revision.

[*By the Academy, June 2, 1892, Vol. IX, p. ii.*]

The secretary was given authority to allow as much as ten dollars for the illustrations of a paper when the contribution was of sufficient value to warrant it. A larger amount than this might be allowed by the Committee on Publication.

[*By the Academy, December 29, 1896, Vol. XI, p. 558.*]

The secretary was directed to add to the date of publication as printed on the outside of author's separates the words, "Issued in advance of general publication."

FEES OF LIFE MEMBERS.

[*By the Academy, July 19, 1870, Vol. I, p. 187.*]

Resolved, That the fees from members for life be set apart as a permanent endowment fund to be invested in Wisconsin state bonds, or other equally safe securities, and that the proceeds of said fund, only, be used for the general purposes of the Academy.

ANNUAL DUES.

[*By the Academy, December 29, 1892, Vol. IX, p. vi.*]

Resolved, That the secretary and treasurer be instructed to strike from the list of active members of the Academy the names of all who are in arrears in the payment of annual dues, except in those cases where, in their judgment, it is desirable to retain such members for a longer time.

ARREARS OF ANNUAL DUES.

[*By the Council, December 29, 1897.*]

Resolved, That the treasurer be requested to send out the notices of annual dues as soon as possible after each annual meeting and to extend the notice to the second or third time within a period of four months where required.

SECRETARY'S EXPENSES.

[*By the Academy, December 27, 1902.*]

Resolved, That the Academy hereby appropriates the sum of seventy-five dollars per annum as an allowance for secretary's expenses, for which a single voucher shall be required.

NOTE.—The Printing Commissioners of the State of Wisconsin now require all copy to be at hand ready for the printer before the permit for printing shall be issued by the Secretary of State. But, under a ruling of the Commissioners, made in response to a presentation by the Committee of the Academy appointed December 29, 1897, each volume of the Transactions may be issued in two consecutive parts; so that a publication may thus be issued each year covering the papers accepted after the previous annual meeting.

ERRATA.

Page 289, l. 9, read "144 mm" instead of "135 mm."

Page 289, l. 20, read ".0576 mm" instead of ".054 mm."

Page 293 at bottom should indicate that C. L. Herrick is author and H. P. Nachtrieb ('95) is merely editor.

Page 289, line 9, read "144 mm" instead of "135 mm."

Page 289, line 20, read ".0576 mm" instead of ".054mm."

Page 372, line 18, for "A > C" read "A < C."

Page 435, line 12, for "This is" read "That is."

Page 465, line 27, for "recognized by" read "recognizedly."

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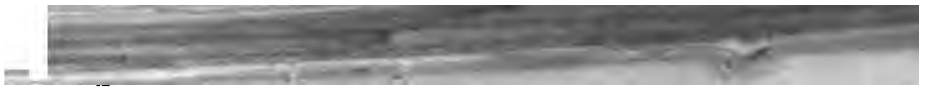
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